INTEGRATED EDITION OF THE PETROLEUM ENGINEER

the Petroleum Engineer

FOR MANAGEMENT

JULY 1959

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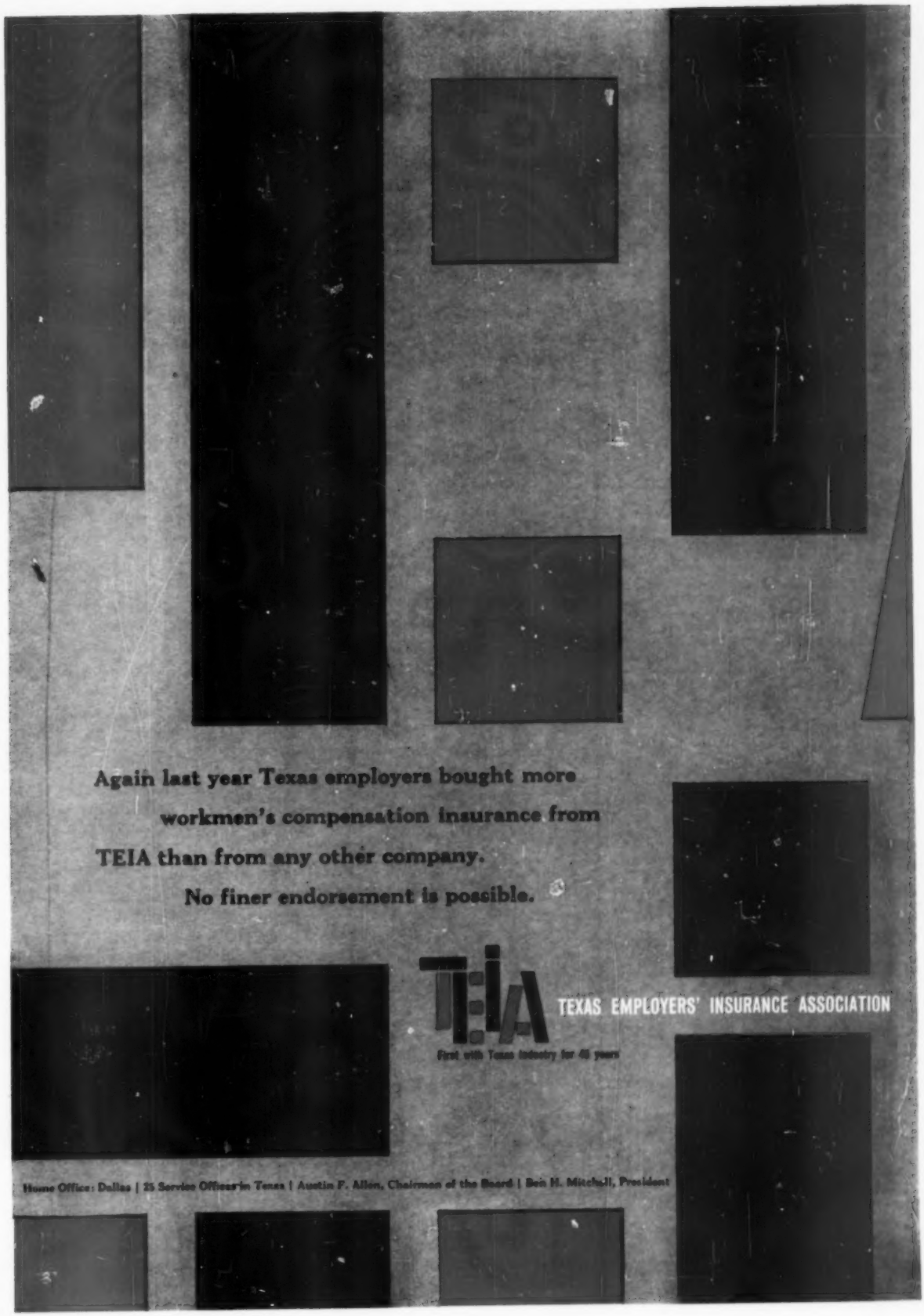
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FOR MANAGEMENT

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— *Ernestine Adams*

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THE PETROLEUM Engineer
FOR MANAGEMENT
INTEGRATED EDITION OF THE PETROLEUM ENGINEER

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A UNITED NATIONS FOR OIL?

THERE WAS a time when the petroleum industry was thought of largely in terms of the United States.... we produced most of the oil, had the most reserves, and were the biggest consumers. Whatever the problems were, they were our own, to be solved by us.

This situation no longer exists. The petroleum industry today is truly worldwide. Greatest proved reserves are now in the Middle East. Seventy-three countries are producing oil and gas. Consumption is on a definite upgrade throughout the world. Problems today are world problems, to be solved on a community of interest basis.

It is fortunate that there is a World Petroleum Congress.

This international forum, which has just completed its fifth session in New York City, brings together scientists and technologists from all countries that produce oil. This year 285 papers were presented, covering important phases of the industry — geology, exploration, drilling, production, refining, pipelining, conservation, development, marketing, and all the rest.

The more than 200 exhibits provided a means of first hand insight into latest developments in equipment. You could say that this is extending to a universal audience the cooperative spirit that has made possible the interchange of engineering data among U. S. oil companies, both major and independent, a factor that unquestionably has made this country a technological pace setter for many years.

An opportunity is now seen for the World Petroleum Congress to broaden its scope of activity and assume the role of a sort of United Nations of the petroleum industry. Suggested by L. F. McCollum, president of Continental Oil Company, and up for adoption by the Congress, is establishment of an international study group whose purpose would be solution of global problems.

One of these problems is the overabundance of oil worldwide. In the quarter century prior to the early 1950's, global ratio of reserves to production was 20 to 1, it was pointed out, whereas today the ratio is 40 to 1, and increasing. In the past, situations such as this have caused economically wasteful production and marketing practices. McCullum warned against letting this happen globally.

As a requisite to making the problem of global cooperation and advancement workable, he urged: (1) continued free interchange of technological knowledge, (2) countries having potential oil deposits should encourage their discovery and development, (4) all nations should work toward elimination of unnecessary restraints on movement of oil and its products in international trade, (5) parties to voluntary agreements should faithfully observe the terms of their contracts, and (6) oil should not be used as a political weapon in dealings among nations.

Great as is the service it now renders, the World Petroleum Congress can become an even greater instrument in the cause of the petroleum industry.... and in the cause of world understanding and peace as well.

Frank H. Love

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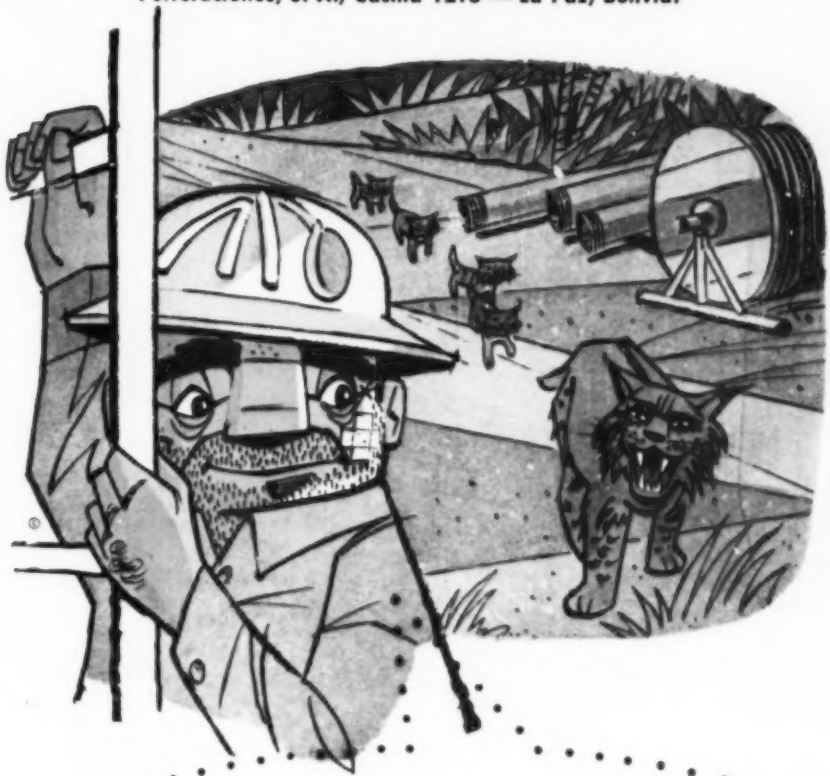

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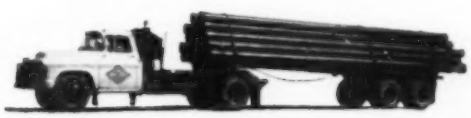

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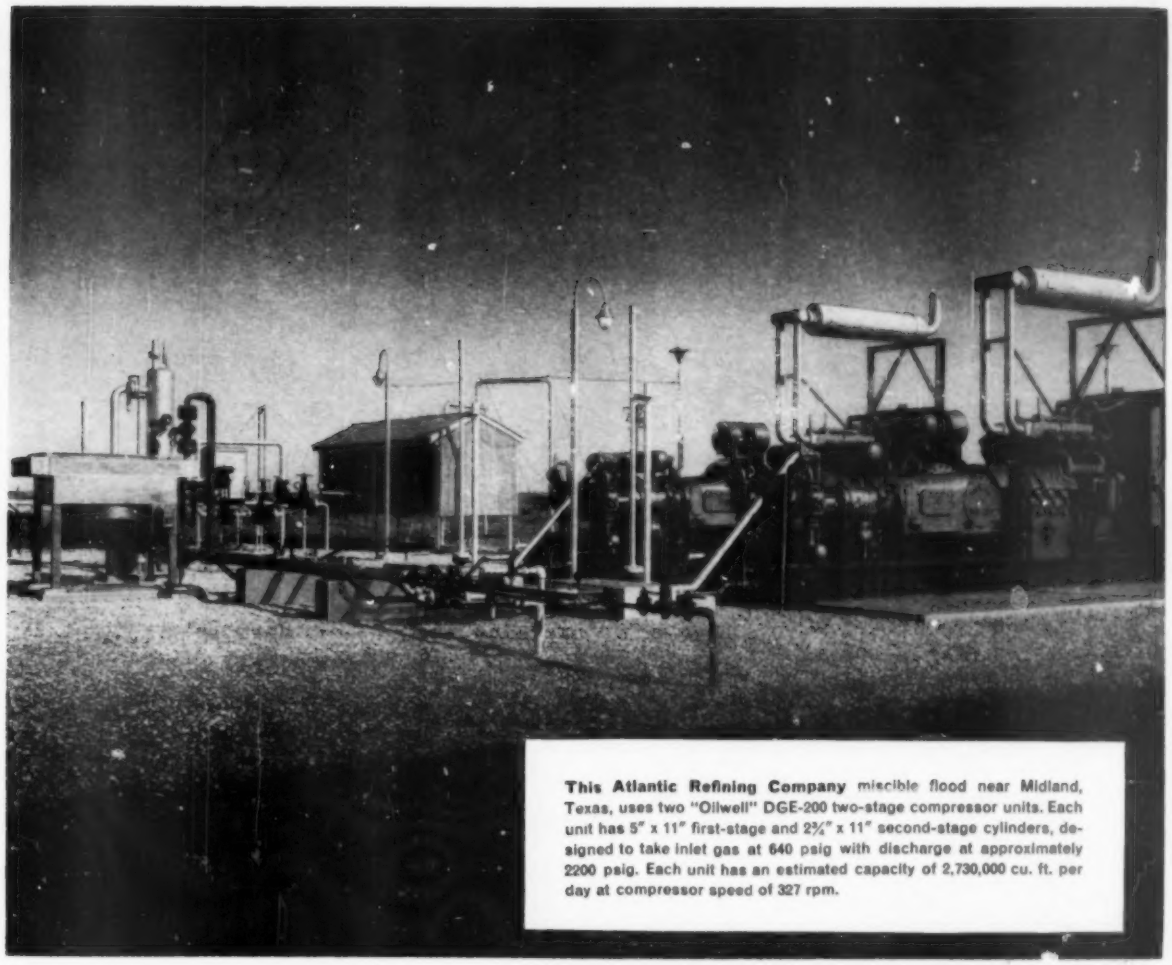

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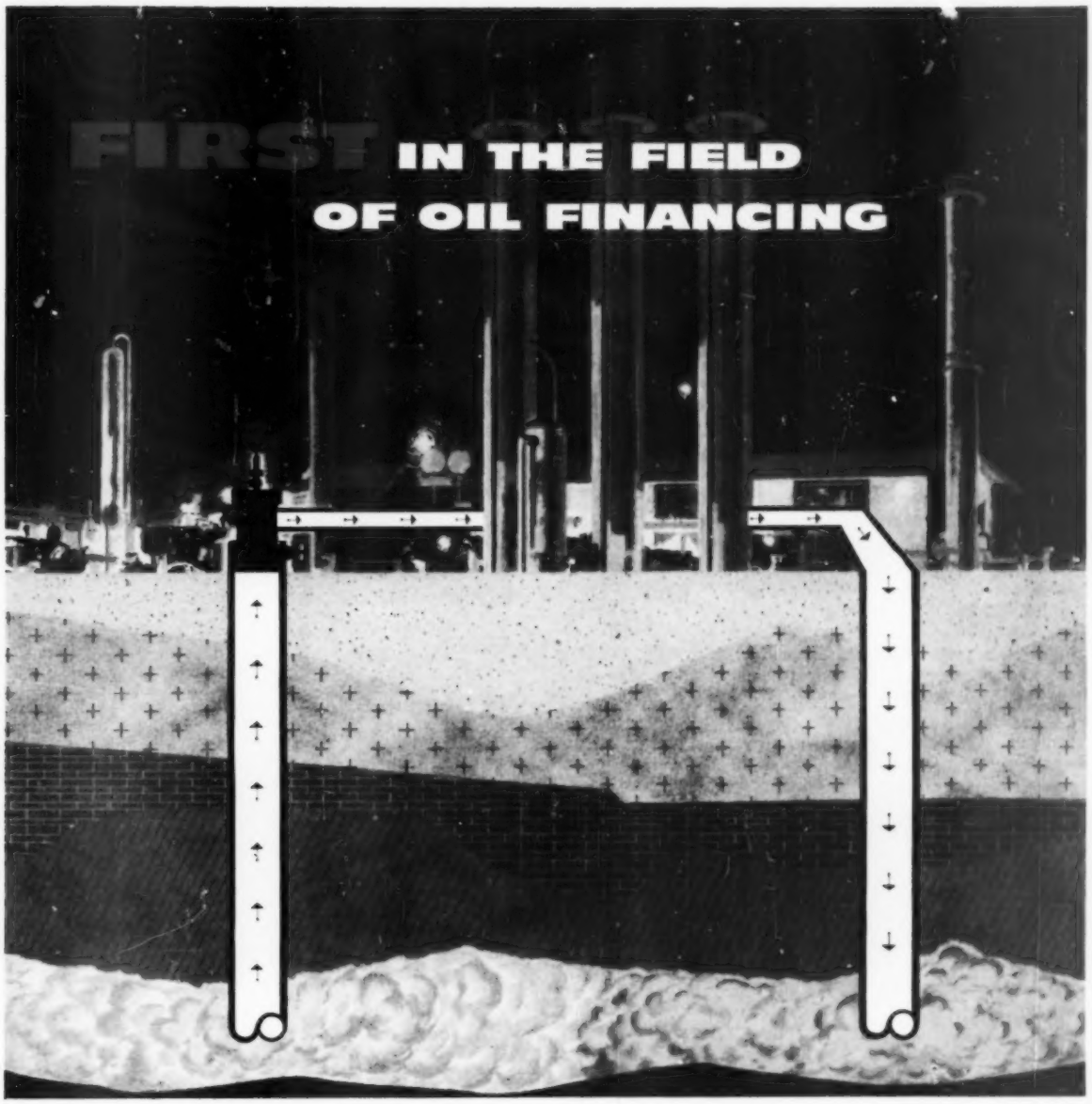

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Petroleum Profile

WHEN ESQUIRE MAGAZINE named "16 Bright Young Men in Business" in 1957, bright (president of company), young (then 30), J. A. "Jack" Vickers was naturally one of them. Jack gets so many honors it is almost embarrassing, but you can't keep from being intrigued by his sort of inverse Horacio Alger story.

A rich boy — a crown prince of industry — whose drive and executive ability have never let him sit down and enjoy the idleness and luxuries his inheritance might have bought, young Vickers is an industry wonder.

When he was 14 years old Jack's father died. A contemporary of Phillips, Marland, Skelly, Sinclair, and other industry pioneers, J. A. Vickers, Sr. formed his company in 1918 when he struck oil in Butler County, Kansas. He had the crude but no way to move it to market, so he built a refinery at Potwin, Kansas, where a spur of the Missouri Pacific Railroad was located. He had laid a solid foundation for the company when he died.

Management continued under various trusts and the older Vickers boy went to school. In 1946 he left the University of Oklahoma to join the company as an oil scout.

Jack became assistant to the vice president in charge of the firm's land department in 1949. In 1952, he was named vice president and assistant to the president, John S. Wertz. When Wertz became chairman of the board he was elected to the presidency. He was 25 years old.

When queried for his successful methods in achieving expansion goals in the space of but a few short years, Vickers is quick to point out that his major achievement in business was to organize an aggressive, first class management team.

The young president early formulated a long range program of expansion, first step of which was completion of a $500,000 products pipeline from the refinery in Potwin to the Great Lakes Pipeline in El Dorado, Kansas. This move opened up new marketing horizons for Vickers.

At the same time, work had begun on an elaborate plant improvement program at Potwin. The Vickers refinery was almost completely re-designed around a $4,000,000 Thermafor catalytic cracking plant.

Vickers' exploration and drilling activities kept pace with plant expansion. In 1953, the company participated in the drilling of the discovery well which opened the Anderson Ranch Unit, Lea County, New Mexico. Vickers Explorations, Ltd. was also organized at this time.

Marketing expansion was not neglected. In 1952, Vickers enjoyed an 88.5 percent sales increase; the next year products sales increased 36.7 percent.

Recognizing the need for a "re-introduction" of the Vickers name in its retail marketing area, Jack Vickers decided to utilize A.A.U. Basketball.

Alongside of such industrial giants as Phillips Petroleum, Goodyear Tire and Rubber, and Caterpillar Tractor, Vickers fielded a team of "name" college stars in the National Industrial Basketball League in 1955 and, in 1959, won the National AAU championship.

VICKERS' BASKETBALL program has been tremendously successful. With reams of publicity on sports pages from coast to coast for six months out of every year devoted to basketball, Jack Vickers has felt his basketball program is responsible for much recognition and good will the company now enjoys. Basketball has been a valuable tool also in such areas as employee relations, management training programs, community and industry relations.

Along with building company-owned outlets, Vickers

J. A. VICKERS

President

Vickers Petroleum Company, Inc.

acquired the Kent Oil Company, a transaction which added 26 retail outlets along with five bulk plants to retail operations in 1957.

In charge of Vickers' marketing is younger brother, James W. Vickers, who said, "The Kent acquisition along with the building of our own retail outlets has helped to stabilize our entire marketing program."

Vickers completed a $1,000,000 Ultraformer at Potwin, which not only became the initial step toward the formation of a chemicals division, but was also added insurance in the octane race. Last year, an Udex extraction unit went onstream to form a $3,500,000 petrochemical complex which helped diversify the refinery even another step. Producing the first benzene ever manufactured in Kansas, the Vickers Chemicals Division, which is producing over 15,000,000 gallons of petroleum aromatics annually, is the first petrochemical plant built by an oil firm in Kansas.

As the company goes into its 41st year guided by the steady hand of Jack Vickers, it holds a unique position in an industry dominated by huge and complex industrial behemoths. Vickers, sometimes called "The Last of the Independents," is so tagged because the company probably is the only completely integrated oil concern in the United States today that is completely family owned.

If you think because he has one of the toughest management jobs in the industry, he keeps his nose to that grindstone you're wrong.

You can't be a company success if your industry isn't prospering and modern managers know that well.

Jack Vickers digs into industry and civic affairs with such good will it is pleasant to work with him. He usually gets an office or holds policy-making jobs for his organizations. Fellow members know he'll get the work done. Right now he is vice president of IPAA, and of Western Petroleum Refiners Association.

He still meets a challenge more than half way. Even better, he takes his organization with him.

THE CONFERENCE TABLE

"No brain is stronger than its weakest think."

Soviet vs USA Economy

"A Glance at the Russian Economy" has been prepared and published by the Research Department of the National Association of Manufacturers. One of its economic series, the booklet goes into a comparison of United States and USSR economics. Conclusion is that in the foreseeable future chances are that Khrushchev cannot make good his threat to "bury the United States economically." The Association's study asserts "that although the Russians have made appreciable, and in some instances amazing, productive gains, they are not at this time an economic threat to the United States."

Rate of growth, however, is higher in the USSR than in the United States in many items, including petroleum and natural gas. Percent growth in production of crude petroleum in the USSR for the 1928-1955 period was 6.9 percent annual average. In the United States it was 3.8 percent for the same period. Natural gas showed 14 percent growth in production for 1928-55 in the USSR and 6.8 percent in the U. S. (See 12th Annual World Round-Up in this issue for USSR activities.)

For those interested, this booklet can be obtained for $1 by writing National Association of Manufacturers, 2 East 48th Street, New York 17, New York.

★ *To me—old age is always 10 years older than I am.*
—Bernard M. Baruch

Let's Get Rid of NPR

President Eisenhower has asked that the U. S. government dispose of the anachronistic Naval Petroleum Reserves. Actually there never was any reason for Naval Petroleum Reserves except one dreamed up by officials who estimated U. S. reserves at a ridiculously low figure. Since then the situation has changed completely. The growth in petroleum consumption, the high reserves in the United States, and the fact that the nation-wide — even the world-wide — petroleum industry must be relied upon in both peace and war.

The Naval Petroleum Reserves comprise a large area in northern Alaska, the Elk Hills and Buena Vista Hills fields in California, and Teapot Dome field in Wyoming. The first reserves at Elk Hills were set aside in 1912. The idea was if the rest of the United States ran out of oil there would still be some left for the navy in these conserved reservoirs.

★ *Whoever will be free must make himself free. Freedom is no fairy gift to fall into a man's lap. What is freedom? To have the will to be responsible for one's self.* —Stirner

Freedoms Foundation Honors Firm

General Petroleum, Los Angeles, was awarded a coveted George Washington Honor Medal by the Freedoms Foundation recently for the company's motion picture *Fire and the Wheel.*

The 28-minute color film, produced by General Petroleum (Socony Mobil affiliate) last year, depicts the job it takes to provide the consumer with a never-ending supply of oil — oil that has given mankind freedom of movement and that has relieved him of much drudgery.

President R. L. Minckler accepted the award for the company from Dr. Kenneth Wells, president of the Freedoms Foundation. On making the presentation, Dr. Wells stated that the honor was given the film because it nurtures the American way of life, and pointed out that of 400 motion pictures reviewed by the foundation in the past 10 years, *Fire and the Wheel* was the second highest in demonstrating the American way of life.

Dr. Wells added that, as a result of the award, *Fire and the Wheel* will be on the Freedoms Foundation's accredited list for schools, colleges and public audiences.

(EDITOR'S NOTE: Information regarding prints of *Fire and the Wheel* for showing to groups may be obtained from the publication office.)

★ *There is no better exercise for the heart than reaching down and lifting somebody up.* —John Andrew Holmes

Count the Cost of Capital

The great investments in all phases of the petroleum industry, which have permitted its growth and expanded service, have been supplied mostly by the industry's withheld earnings and depreciation. Almost 90 percent has come from these sources, according to Bernard T. Stott, vice president First National City Bank of New York, in a World Petroleum Congress address.

He predicts, however, that outside sources of capital funds will be needed more extensively in the future. Increasing costs and taxes will leave less money available for internal financing.

This appears to be an added cost that eventually consumers will find added to prices of products. It is a legitimate cost, however, and it will be interesting to see how it will affect the industry's fiscal structure.

Dividends will perhaps have to go higher to attract capital in the market and prices of shares will move more slowly.

A more concerted effort may be made to get depreciation at cost of replacement. At present, earnings are paying for capital that disappears because of unrealistic depreciation as well as for expansion. Inflation and technological progress often have earnings on the run to keep a company in the same spot.

One More River to Cross

"In addition to the efficient and imaginative coordination of people, capital, materials and technology, management must do what it can to create a political climate conducive to the free play of industrial efficiency and imagination.

"What ends are we serving when capital, management and technology are strained to improve the quality of products while holding down their costs, only to have the successes of such a program dissipated by unreasonable demands by labor, constantly increasing and disproportionate motor fuel taxes and various forms of governmental interference?"

W. L. Naylor, Senior Vice President, Gulf Oil

5 and 11 Zeros

At the end of the first quarter this year, life insurance ownership in the U. S. hit a dizzy half-trillion-dollar peak — that's $500 with nine zeros following.

Highlights

★ ★ ★

Extra Fast Changes

Do you realize it was only two months ago that the unions were marching on Washington to dramatize the unemployment in the United States? Since then records have been made in employment and unemployment insurance-paid workers has dropped also.

Only a few economists realize that the dip in our recession in 1958 was about April — the early part of the year. Throughout the rest of the year the conservatives were fighting in Congress to hold back federal spending demanded for the recession. It looks like what we need are better, quicker, faster statistics.

Nine Governors Attend IOCC

The annual mid-year meeting of the Interstate Oil Compact Commission in New Orleans, Louisiana, was attended by nine governors. These included Governors J. Hugo Aronson, Montana, chairman of the Commission; John Patterson, Alabama; Paul Fannin, Arizona; John Burroughs, New Mexico; George Docking, Kansas; Howard Edmondson, Oklahoma; Price Daniel, Texas; and J. J. Hickey, Wyoming. One of the featured speakers at the June 15–17 meeting was Capt. M. V. Carson, administrator of the oil imports program, who explained the workings of the mandatory program established by President Eisenhower.

Russia's 'Token' Boycott of Congress

The much-publicized USSR boycott of the Fifth World Petroleum Congress in New York, June 1–6, was a "token" gesture, it seems. Actually six Iron Curtain nations had representatives among the 6000 attending the Congress. Russia officially boycotted the meeting, withdrawing its presentation of several papers, but had five "observers" present. Satellite countries with official delegations included Czechoslovakia, Finland, Hungary, Poland and Rumania. Rumania was among the 27 countries presenting technical papers before the group.

Ohio Oil Purchases Aurora

Ohio Oil Company is bringing its crude production into balance with refining volume through the stock-exchange acquisition of Aurora Gasoline Company of Detroit, Michigan. Aurora, at stock market prices valued near $40,000,000, has a refining capacity of 65,000 bbl per day from three Michigan units. The closely-held refining and marketing firm is the largest independent in its field in Michigan and has for several years purchased much of Ohio Oil's crude. Through Aurora's subsidiary, Speedway Petroleum Corporation, it markets products through 660 stations concentrated mostly in the Detroit area and is a supplier of unbranded products in Wisconsin and Canada. Aurora will continue to operate as a wholly-owned subsidiary of Ohio, under present policies, and retail and wholesale operations will remain under the "Speedway 79" brand.

Conoco Acquires Kendall, San Jacinto

Continental Oil Company has controlling interest in two additional oil companies. The F. P. Kendall Oil Company of Chattanooga, Tennessee, one of the leading independent marketers in the Southeast, has been purchased. Continental, completing its transaction with San Jacinto Petroleum Corporation, is now holding about 75 percent of the stock.

New shares of Continental stock are being issued for the assets of Kendall Oil. After acquisition is complete, the company will continue to operate under present management and its own marketing practices and policies and will retain its "Kayo" brand name. Kendall employs 650 and markets products in service station outlets in Tennessee, Georgia, Alabama, Florida, North and South Carolina, Virginia and West Virginia.

Conoco gained two-thirds of San Jacinto's common stock in exchange for 824,000 shares of Continental stock. In addition Continental has gained 10 percent of San Jacinto stock from several major stockholders. This company also continues to operate as a separate corporation under present management.

Nation to View Wildcat on TV

Dave Garroway's NBC "Today" show is taking its nationwide television audience to look in on developments at the drilling of a wildcat well near Enid, Oklahoma. Garroway will look in on the well June 25, July 2, 16 and 30, and August 13 and 27. Interviewers plan to talk to the crews of Big Chief Drilling Company, who holds contract on the well, the geologist, the landowner, and Carl and Henry Gungall, independent operators. On the final visit to the well site, "Today" cameras will go to Titusville, Pennsylvania, where Drake discovered oil 100 years ago. Coverage of the drilling project is an outgrowth of the show's interest in bringing a greater understanding of various phases in American industry to TV viewers.

Gasoline Consumption Hits Record

Gasoline consumption in the U. S. hit a new peak of 59,154,000,000 gal in 1958 — an increase of 1.75 billion gal over the 1957 figure. The American Petroleum Institute, which released the figures in its annual report on consumption, states that about 90 percent of the gasoline used involved highway travel and therefore is subject to taxes. The tax "take," by federal, state, and local governments is estimated (averaging 9 cents per gal) at $4,670,000,000 annually. Of the total, California consumed 5.7 billion gal; Texas, 4.7 billion gal; New York, 4 billion gal.

The Traffic Jam

Motor vehicle registrations continue to rise, reports the government. The 1958 total reached 68,299,408 in the U.S. — a gain of 1,168,337 over 1957 registration, reflecting a 1.7 percent increase. Largest increase was in bus registration, 2.3 percent more than in 1957. Trucks on the road increased 1.8 percent. The number of passenger cars increased 1.7 percent in 1958. The 1958 total included 270,163 buses, 11,158,561 trucks and 56,870,684 cars. Registrations paralleled domestic gasoline demand during the period.

IPE Looks At Record

The crowds gone and the exhibits disassembled, International Petroleum Exposition officials have taken a look at the long list of shattered records. The fourteenth oil show at Tulsa, which ended May 23, counted 547,000 in attendance — far exceeding the previous record of 395,352 set in 1953. Foreign visitors numbered 2042, representing 54 countries, as counted by the Nomads. It is estimated that some 32,000 oil men who specify and purchase equipment and services passed through the IPE gates. And they did buy! Sales figures were estimated at near one-half billion dollars. President of IPE, W. K. Warren, is looking forward to the next oil show in Tulsa in 5 or 6 years. The date will probably be set in 1961.

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Highlights ★ ★ ★

Pemex Counts U. S. Debt

Petroleos Mexicanos' debt to U. S. oil companies now totals "only" $34,720,000, reports the Mexican government-owned oil company. The amount due, incurred as a result of the 1938 expropriation, will be trimmed again soon with the annual payments made each September to the deposed firms. Officials say the total amount will be liquidated "within the next few years," then Pemex will have funds available for reinvestment in expansion programs.

Oil Commemorative Stamp Revealed

A special 4-cent stamp will be released August 27 to commemorate the centennial of the petroleum industry. The special issue was designed by New York artist Robert Foster. Color of the stamp has not been announced by the U. S. Postal authorities. The stamp will first enter the mails at Titusville, Pennsylvania, home of the oil industry, on August 27, but will be available after that date at all U. S. Post Offices. Anyone desiring first-day cancellations of the new stamp may send addressed envelopes, together with remittance to cover cost of the stamps to be affixed to: First Day Covers Petroleum Industry Stamp, Postmaster, Titusville, Pennsylvania. Centennial envelopes may be obtained from API Centennial Headquarters, 50 West 50th Street, New York 20, New York, at 4 cents each.

Pauley Petroleum Integrates

Through the purchase of Newhall Refining Company, Inc., the Pauley Petroleum, Inc. has entered the refining field. Newhall, which operates a 3000 bbl per day plant at Newhall, California, will retain its present name and be operated as a wholly-owned subsidiary of Pauley Petroleum. W. D. Parks, Newhall president, will continue in that position, while Raymond Kerr and Edwin Pauley, Jr., executives of Pauley Petroleum, will become vice presidents. An expansion program has been set which will increase the refinery's refining capacity more than 50 percent, in addition to upgrading the quality of its products, primarily asphalts and heavy oils.

Petroleum Electric Power Association's new officers for 1959-60 term elected at the 31st Annual Conference in Galveston, Texas, June 10, are, left to right: W. M. Larkin, Gulf States Utilities Company, Lake Charles, Louisiana, vice president; D. S. Coffman, Texas Power and Light Company, Dallas, president; and B. F. Thompson, Public Service Company of Oklahoma, Tulsa, secretary-treasurer.

Imports Hearings Net Little

Devoted to making the federal oil imports program work, Capt. M. V. Carson and the oil imports appeals board have yielded little in new imports allotments. In most instances, oil companies applying for new or increased import allotments have been given prompt, courteous service — but no alleviation from many problems stemming from restrictions. The appeals board has 78 appeals on file, and has ruled on 57 of them. Only six have given any relief in the form of increased allotments. The total of relief is less than 13,000 bbl daily of crude, residuals and propane.

George F. Getty II, president of Tidewater, however, claims that he is getting no answers to his inquiries regarding a March 13 decision. New imports tables set this month, says Getty, "Represent social legislation within the industry which has no relationship to or proper place in the overall program of limiting imports in the interest of national security."

Sixth World Congress in Germany

West Germany will be the site of the Sixth World Petroleum Congress, the executive council voted at the recent New York meeting. To be held "within the next five years," Congress officials say that exact date and location will be determined by a local committee. To guide future activity of the Congress, Sir Stephen Gibson of London was elected chairman of the permanent council. Gibson was managing director of Iraq Petroleum Company from 1950 to 1957.

Meetings

Aug. 8-11 — **Louisiana Gulf Coast Oil Exposition Week, Lafayette, La.**

Aug. 9-12 — **ASME-AIChE, heat transfer conference, University of Connecticut, Storrs, Conn.**

Aug. 10-13—**Society of Automotive Engineers, West Coast meeting, Hotel Georgia, Vancouver, B. C.**

Aug. 23-26 — **American Institute of Electrical Engineers, electrical conference, Wilton Hotel, Long Beach, Calif.**

Aug. 24-26 — **Appalachian Gas Measurement Short Course, West Virginia University, Morgantown, W. Va.**

Sept. 7-10 — **Institute of Management Sciences, annual international meeting, Paris, France.**

Sept. 15-17 — **Texas Mid-Continent Oil & Gas Association, annual meeting, Rice Hotel, Houston, Texas.**

Sept. 16-18—**National Petroleum Association, annual meeting, Traymore Hotel, Atlantic City, N. J.**

Sept. 17 — **Natural Gasoline Association of America, Rocky Mountain regional, Gladstone Hotel, Denver, Colo.**

Sept. 20-23 — **American Society of Mechanical Engineers, petroleum mechanical engineering conference, Rice Hotel, Houston, Texas.**

Sept. 23-24 — **Western Petroleum Refiners Association, Rocky Mountain regional technical-industrial relations meeting, Henning Hotel, Casper, Wyo.**

Sept. 27-30 — **API, executive committee of board of directors, Greenbrier Hotel, White Sulphur Springs, W. Va.**

Sept. 28-Oct. 1 — **The American Welding Society, fall meeting, Sheraton-Cadillac Hotel, Detroit, Michigan.**

Sept. 29-30 — **Western Petroleum Refiners Association, management seminar, Western Hills, Wagoner, Okla.**

Oct. 1-2 — **National Association of Corrosion Engineers, southeast region conference, Jacksonville, Fla.**

Oct. 4-7 — **Society of Petroleum Engineers of AIME, annual fall meeting, Dallas, Texas.**

Oct. 5-7 — **American Gas Association, convention, Conrad Hilton Hotel, Chicago, Ill.**

Oct. 5-7 — **National Association of Corrosion Engineers, northeast region conference, Lord Baltimore Hotel, Baltimore, Md.**

Oct. 7-8 — **Western Petroleum Refiners Association, annual waste disposal and pollution conference, Broadview Hotel, Wichita, Kans.**

Oct. 8-9 — **California Natural Gasoline Association, annual fall meeting, Huntington-Sheraton Hotel, Pasadena, Calif.**

Oct. 8-10 — **American Association of Petroleum Geologists, annual meeting of the Southwestern Federation of Geological Societies, Lubbock, Texas.**

Oct. 11-13 — **American Association of Oilwell Drilling Contractors, annual meeting, Skirvan Hotel, Oklahoma City, Okla.**

Good Wells Make Good News

Recent Treatments Engineered With the Aid of the "Frac Guide"

July 1, 1959

The "Frac Guide*" -- a Dowell-developed manual used in engineering frac jobs -- is revolutionizing fracturing techniques. Here are four recent treatments that show improved results obtained with the "Frac Guide."

- **Atascosa County, South Texas** (Old Oil Well) This well was completed into the Navarro formation at 5043 feet. After production had dropped to almost nothing, the well was refractured. 15,000 gallons of lease crude and 30,000 pounds of sand failed to help. Then Dowell engineered a treatment with the "Frac Guide." Riverfrac* was selected as the frac service; and 100,000 gallons of fresh water and 100,000 pounds sand were injected down casing, creating a calculated fracture area of 126,000 square feet. Production climbed to an average of 21 bopd and showed no sign of decline after 60 days. Treatment paid out in about 65 days.

- **Beaver County, Oklahoma Panhandle** (New Gas Well) This well, completed through perforations into the Lower Morrow sand at 7831-46 feet, tested 750,000 cfd open flow. Dowell engineers designed a treatment with the "Frac Guide" and recommended Waterfrac. 10,000 gallons of thickened water and 44,000 pounds sand were pumped into the well, creating a calculated fracture area of 50,000 square feet. After clean-up, production was 35 mmcfd on potential test. Other wells in the area, fractured with 20,000 gallons gelled oil and 20,000 pounds of sand -- the standard treatment in the Lower Morrow before the advent of the "Frac Guide" -- usually test only about 8 mmcfd.

- **Natrona County, Wyoming** (New Oil Well) This well produced only 16 bopd from the Second Wall Creek formation at 4256 feet. With the "Frac Guide", Dowell engineered a treatment using Sandfrac*. 38,000 gallons of lease oil with F.L.A.* (Fluid Loss Additive) and 105,000 pounds of sand were injected into the well. The calculated fracture area created was 123,000 square feet. Production 60 days after treatment was 65 bopd. Smaller jobs in this field, using only 1½ pounds of sand per gallon, usually result in only about 35 bopd.

- **Alberta, Canada** (Old Oil Well) Based on core analysis and previous experience, a major operator considered abandoning a well completed in the Cardium at about 4411 feet. Then Dowell engineered a treatment using the "Frac Guide", and injected 5000 gallons of 40 gravity lease crude carrying 25,000 pounds of sand down tubing. A calculated fracture area of 36,000 square feet was created. The operator feels certain that the well will now make its allowable; and that a commercial well could not have been obtained using previous fracturing techniques.

Let your Dowell engineer help you plan your next fracturing job. There is no additional cost. Contact the Dowell office or station nearest you. There are more than 165 locations in the United States, Canada, Venezuela and Argentina. Dowell, Tulsa 1, Oklahoma. *Dowell Trademark.

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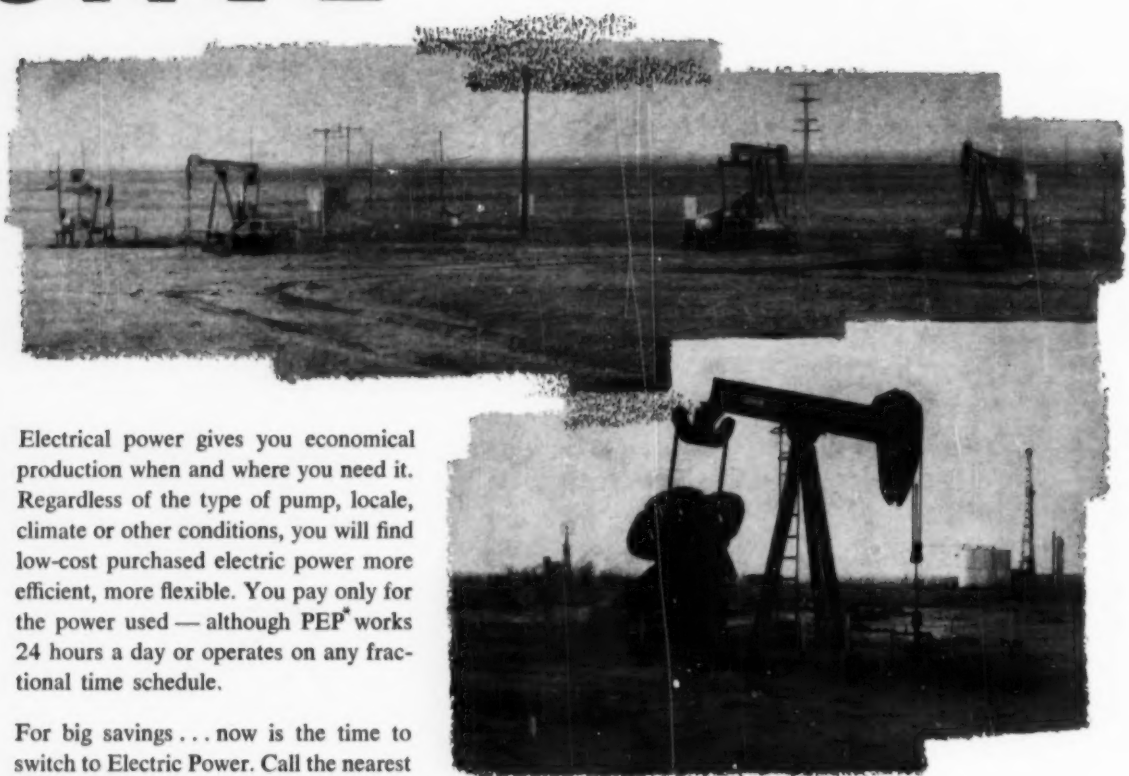

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First Quarter Promising

First quarter reports read well. The percentage rise throws a glow on the picture that results from the contrast to the first quarter in 1958, when the industry was in a slump.

The profit margin moved up slightly. Earnings were 8.6 percent of revenue in the first 1959 quarter compared to 7.7 percent in the 1958 period. This is still far from a satisfactory margin, but the trend is encouraging.

Earnings showed a 21 percent rise with a wider than usual range for the 71 companies. Tidewater made a rebound of 1203 percent from 1958 first quarter earnings. Delhi-Taylor had a spectacular increase of more than 1000 percent. Yet 13 companies had lower net incomes than in 1958.

Revenues moved up 7 percent from 1958, less than earnings, which of course accounted for the greater margin of profit.

The first quarter is promising but the trend is not as firm as we might wish. The industry pattern is still in its changing stage.* Each company seeks its own balance at the same time the industry itself walks a wire with precarious equilibrium between supply and demand.

Sometimes companies within the supply-demand struggle for balance are individually achieving their own adjustments to cope with competition.

Atlantic Refining, which made a good record this first quarter, has increased its needed crude oil production. Tidewater had the largest increase of proved reserves in a dozen years.

Several records were made in the first quarter of 1959. Clark Oil and Refining made its highest revenues and earnings. Sinclair's total sales of refined products exceeded 2 billion gallons for the first time in any quarter.

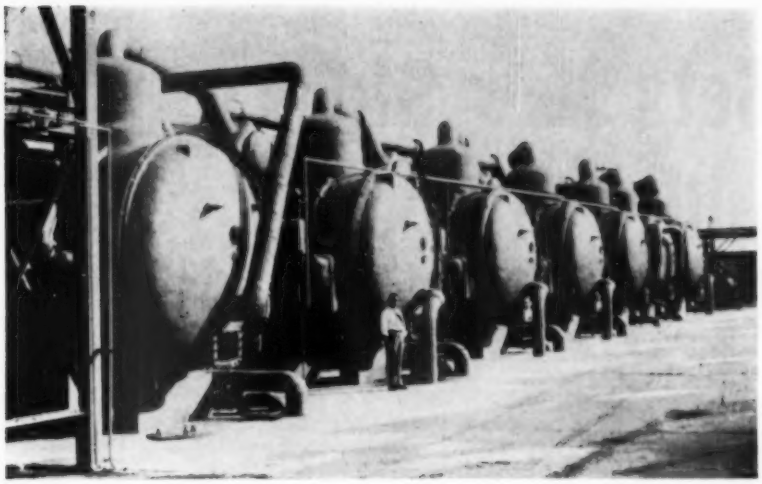
As Standard Oil (Indiana) warned, however, "It would be a mistake to project our first quarter results into a prediction of what the year as a whole may bring."

*See "1958 Revises Industry Pattern," The Petroleum Engineer, May, 1959, Page A-21.

FIRST QUARTER STATEMENTS OF PETROLEUM COMPANIES

Company	Gross Income ($1000) 1958	Gross Income ($1000) 1959	Percent Change	Net Income ($1000) 1958	Net Income ($1000) 1959	Percent Change
Amerada	26,950	27,707	+ 3	5,551	6,383	+ 15
Anderson-Prichard	17,266	17,908	+ 4	659	1,347	+104
Argo	3,367	3,509	+ 4	1,500	1,435	— 4
Ashland O & R	70,962	79,613	+ 12	2,466	3,933	+ 59
Atlantic Refining Co.	145,710	156,154	+ 7	2,695	11,902	+342
Aztec	682	1,915	+181	201	1,270	+532
Bishop	549	505	— 8	27	5	— 81
Blackwell	370	406	+ 10	(14)	87	+116
Champlin O & R	15,726	17,667	+ 12	1,302	2,224	+ 71
Cities Service	287,285	280,046	— 2	13,504	13,661	+ 1
Coastal States	810	1,246	+ 54	287	584	+103
Clark Oil & Refining	17,665	21,135	+ 20	159	504	+216
Colorado O & G	8,055	10,317	+ 28	330	426	+ 29
Continental	155,826	165,416	+ 6	10,699	14,379	+ 34
Cosden[1]	22,597	20,283	— 10	1,099	1,246	+ 13
Crescent	3,436	5,303	+ 54	470	686	+ 46
Delhi-Taylor	16,873	22,578	+ 34	(246)[2]	2,509	+1098
Eason	1,029	1,022	— 7	215	193	— 22
Fairmont	2,230	2,386	+ 7	715	787	+ 10
Frontier	5,986	7,202	+ 20	46	170	+370
General American	5,840	6,944	+ 19	1,660	1,256	— 24
General Crude	2,971	3,549	+ 19	698	944	+ 35
Getty	8,652	9,391	+ 9	7,070[3]	2,677	— 62
Gulf	—	—	—	60,668	66,673	+ 10
Honolulu	10,564	11,294	+ 7	3,398	3,485	+ 3
Hugoton	2,301	2,620	+ 14	1,147	1,273	+ 11
Husky	6,265	6,969	+ 11	195	193	— 1
Intex	782	606	— 23	265	47	— 82
Kendall Refining	4,563	5,118	+ 12	128	158	+ 23
Kerr-McGee	29,289	39,942	+ 36	1,272	2,535	+ 99
Louisiana Ld. & Expl.	8,709	8,737	0	4,800	4,264	— 11
Leonard Refineries	14,546	15,246	+ 5	494	337	— 32
Macmillan	3,555	3,537	— 1	(105)	41	+ 37
Maracaibo	479	450	— 6	91	66	— 27
Midwest Oil	4,674	5,005	+ 7	1,875	1,710	— 8
Monterey[3]	11,668	11,741	+ 1	1,490	1,242	— 17
Mountain Fuel Supply	8,990	10,416	+ 16	1,624	1,946	+ 20
Murphy[4]	7,457	11,465	+ 54	316	1,021	+223
Ohio Oil	71,862	75,165	+ 5	8,368	10,198	+ 22
Phillips	261,727	299,825	+ 15	20,517	25,833	+ 26
Plymouth	23,681	27,000	+ 14	870	1,527	+ 95
Producing Properties[1]	791	1,780	+125	(182)	(403)	—
Pure	122,869	130,232	+ 6	4,732	5,591	+ 18
Quaker State	12,467	14,457	+ 16	289	447	+ 55
Richfield	60,974	66,989	+ 10	5,605	5,585	0
Shamrock[4]	13,985	13,603	— 3	2,524	2,382	— 6
Shell	410,147	452,218	+ 10	30,500	34,467	+ 13
Signal	37,950	39,046	+ 3	4,210	4,330	+ 3
Sinclair	325,955	337,249	+ 3	15,219	17,184	+ 13
Skelly	64,021	68,814	+ 7	6,014	6,695	+ 11
Socony Mobil	—	—	—	36,900	45,200	+ 22
Southland Royalty	2,358	2,592	+ 10	1,003	1,131	+ 13
Standard (Calif.)	391,853	397,182	+ 1	57,411	57,597	0
Standard (Ind.)	478,522	520,205	+ 9	31,432	44,684	+ 42
Standard (N. J.)	1,890,000	2,018,000	+ 7	146,000	167,000	+ 14
Standard (Ohio)	97,539	104,952	+ 8	4,318	8,505	+ 97
Sun	168,610	203,099	+ 20	6,174	11,227	+ 82
Sunray Mid-Continent	89,321	95,550	+ 7	9,653	9,743	+ 1
Superior[4]	27,197	35,109	+ 29	5,028	7,394	+ 47
Texaco	—	—	—	70,003	91,220	+ 30
Texas Gulf	4,182	4,445	+ 6	1,165	1,219	+ 5
Texas Pacific C & O	5,841	6,721	+ 15	1,496	2,020	+ 35
Tidewater	133,048	139,055	+ 5	803	10,463	+1203
TXL[4]	2,926	3,369	+ 15	943	1,148	+ 22
Union Oil of Calif.	96,990	100,426	+ 4	4,327[5]	4,890	+ 13
Union O & G of La.	8,712	11,640	+ 34	2,216	3,651	+ 65
Universal Consol.	2,193	2,003	— 9	482	780	+162
White Eagle	3,402	3,695	+ 9	89	320	+260
Wilcox	2,394	2,018	— 16	189	216	+ 14
Woodley	1,943	2,209	+ 14	640	668	+ 4
Western Natural Gas	2,526	2,723	+ 8	677	819	+ 21
TOTAL	$5,750,665	$6,176,719	+ 7	$608,367	$737,330	+ 21

[1] 3 months ending January 31.
[2] Loss.
[3] 6 months ending February 28.
[4] Quarter ending February 28.
[5] Exclusive of non-recurring capital gain.
[6] Includes dividend income of $3,002,000; none in 1959.



Salt water becomes drinking water in these huge evaporators, part of the world's largest single installation for converting sea water to fresh water.

Sea Water Converted

Giant installation can provide 2.7 million U. S. gallons of fresh water a day at an estimated cost of $1.75 per 1000 gallons

THE WORLD'S LARGEST single installation for converting sea water to fresh water was completed in Aruba, a small semi-arid Dutch island in the Caribbean Sea, some 15 miles off the Venezuelan Coast.

The $11,000,000 plant, designed and built for the Aruban Government by the engineering firm of Singmaster & Breyer, is the first ever constructed which combines salt water distillation with production of marketable surplus electricity (15,000 kilowatts installed capacity).

This combination opens the door to lower prices for fresh water in many parts of the world, because proceeds from the sales of surplus power could be applied to the cost of water production.

Production cost in Aruba has been tentatively estimated as $1.75 per 1000 gal of fresh water. Price to the consumer is of course greater, since it includes distribution expenses.

The Aruba plant has a rated capacity of 2,700,000 U.S. gal of distilled water per day. This is more than enough to supply all of the potable water requirements of the island's 55,000 inhabitants. A substantial quantity is also piped to the island's major industry—the vast refinery of the Lago Oil & Transport Company, Ltd., a Jersey Standard subsidiary.

The fresh water is produced from sea water by the submerged-coil multiple effect distillation process. Sea water is heated and evaporated in one evaporator or "effect"; then the latent heat released by condensation of this vapor is used to evaporate the brine in the next effect, and so on.

At Aruba, by thus using a series of six effects, one pound of steam can produce 4.88 lb of fresh water. Plants with more or less than six effects are possible, but engineers found that this number gave the optimum yield for the capital investment.

For flexibility, the Aruba plant has five independent sets or "lines" of sextuple-effect evaporators. Each line has a capacity of 540,000 U.S. gal per day of fresh water.

Unique feature is production of both distilled water and marketable surplus electricity. Source of energy for both products is heavy residual fuel oil from the Lago refinery. The oil is burned in two Babcock & Wilcox 200,000 lb per hr boilers (one a standby) which operate at 875 psig and 820 F. Makeup is distilled water from the evaporators; there are two 500-hp boiler feed pumps.

Steam from the boilers enters two turbo-generators, each rated 7500 kilowatts at 0.75 power factor. They exhaust against a backpressure of 20 psig. The turbine exhaust, which is fed to the evaporators, varies with electrical demand, and so any steam supply deficiency is made up by reducing and desuperheating the high pressure steam. Additional turbines can be added in the future and fed from the second boiler if local electrical demand warrants.

Key to the high plant efficiency is the "Scalemaster," a special process which prevents salts in the concentrated brine from depositing on equipment surfaces. Since there will be no scaling whatever at normal operating temperatures of 225 F and less, the usual extensive down-time and descaling of sea water distillation plants is eliminated. The Scalemaster is supplied by G. & J. Weir Ltd. (Glasgow, Scotland) who also furnished the evaporators. Its proven success is based on a ferric chloride treatment of the sea water which keeps dissolved calcium and magnesium salts in solution.

The Caribbean Sea, with a salt content of 35,000 parts per million and a temperature of 85 F, is the source of water. The sea water enters a concrete intake chamber at the water's edge several hundred feet from the plant. Here it is chlorinated to kill barnacles and algae which would otherwise clog pumps and piping. Vertical pumps in the chamber force the water through aboveground piping to the distillation plant.

This distillate is split into two streams, one for Aruba and one for the Lago refinery. That for Aruba has its low pH corrected to 7.2 and its taste improved by passage over coral limestone and by aeration. It is then chemically treated to raise its pH to 8.3, filtered, and stored in four 3,300,000 gal aboveground steel tanks, ready for distribution to Aruban consumers. The water for Lago has its pH adjusted by chemical treatment.

* * *

Kellogg Sets New Standards of Reliability in Microwave

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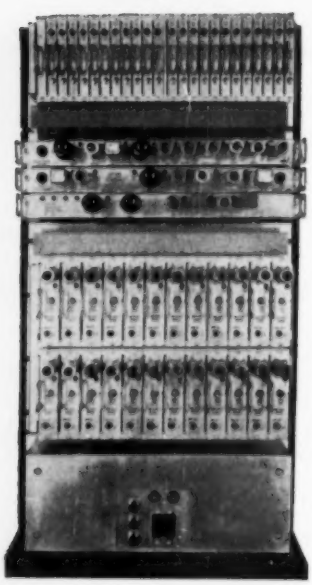
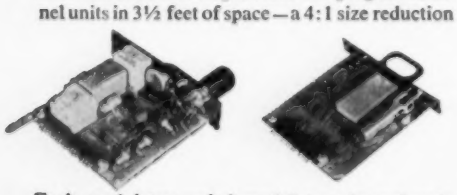


New MICROPLEX provides 23 plug-in channel units in 3½ feet of space—a 4:1 size reduction



Each modulator and demodulator channel unit features printed circuitry.

Microwave was pioneered by ITT in 1931 with the Channel crossing from Calais to Dover. Today Kellogg Microwave is achieving new levels of reliability: 99.998%, far superior to wire line systems! Operating in dozens of installations throughout the world, Kellogg's *complete* communications package includes:

- *Microwave* — operating in the 2,000 and 10,000 megacycles bands.
- *Terminating Equipment*—for automating functions, including teletype, telemetering, remote control, data transmission.

Part of the Kellogg 10-C Microwave System is the new 10-C-2 "Microplex": a 23 or 45 channel PTM multiplexing equipment. It features printed circuits, miniaturized components, minimum maintenance, and occupies only three-and-one-half feet of rack space. All demodulators are semi-passive—only one tube per channel; modulators are passive—no tubes. The 23 channels use 41 tubes with an input of 180 watts—a 5:1 reduction in power consumption.

MICROPLEX may also be packaged in one seven-foot rack to provide 45 channels; or 23 channels with two-wire termination and tone signaling. Signal crosstalk is 62 db and signal-to-noise (F1A) is 70 db for 23 channels.

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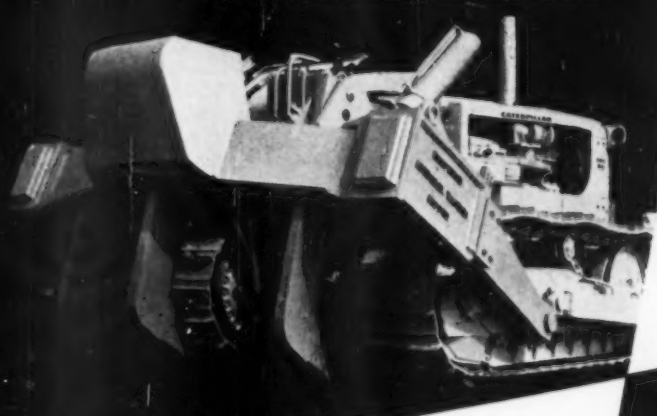

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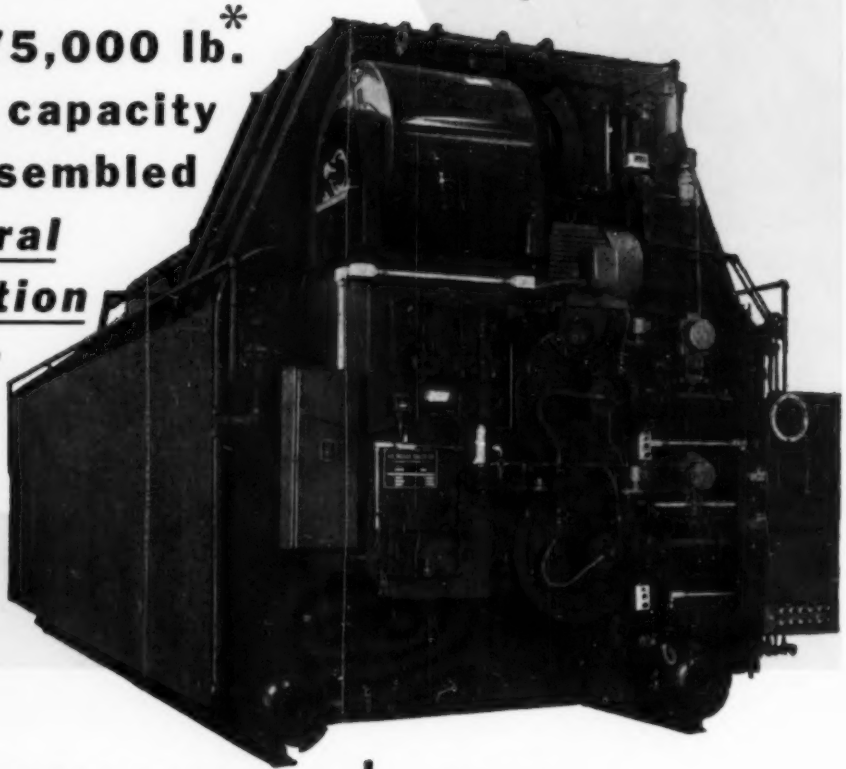

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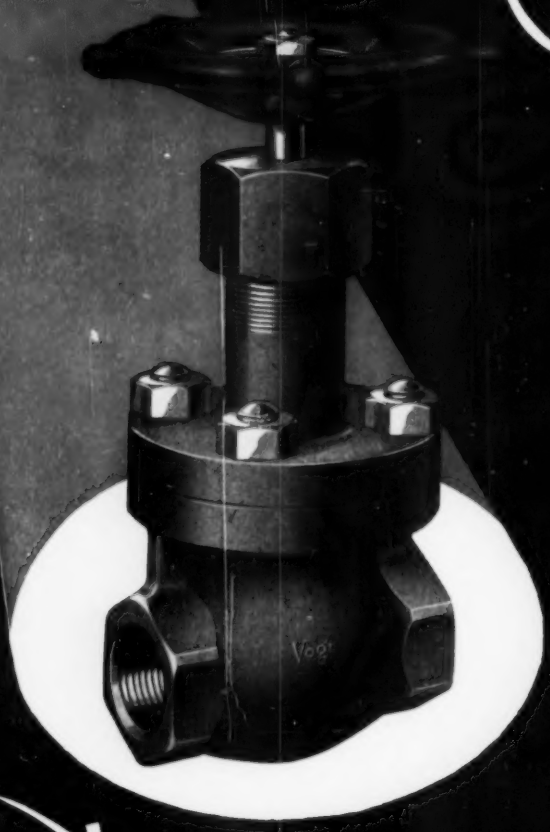

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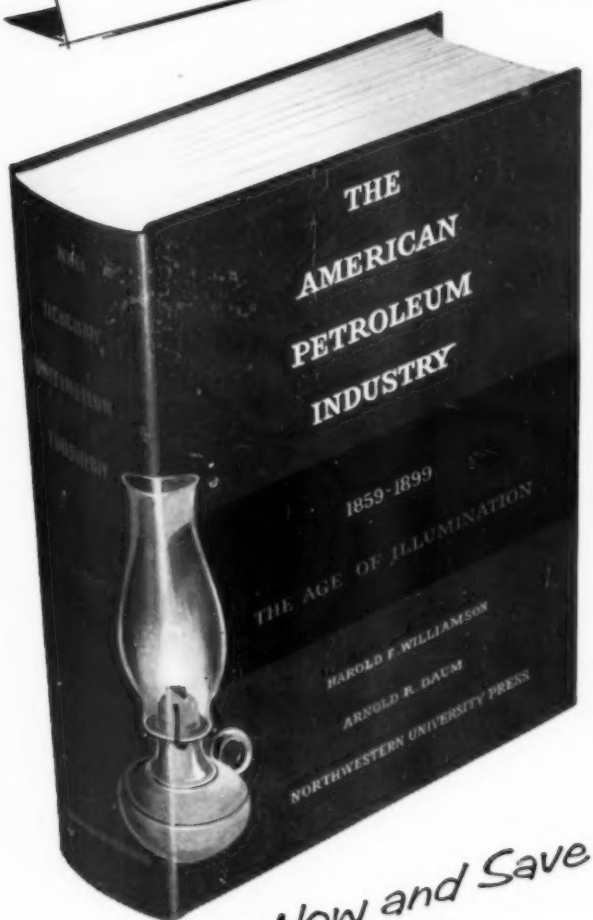

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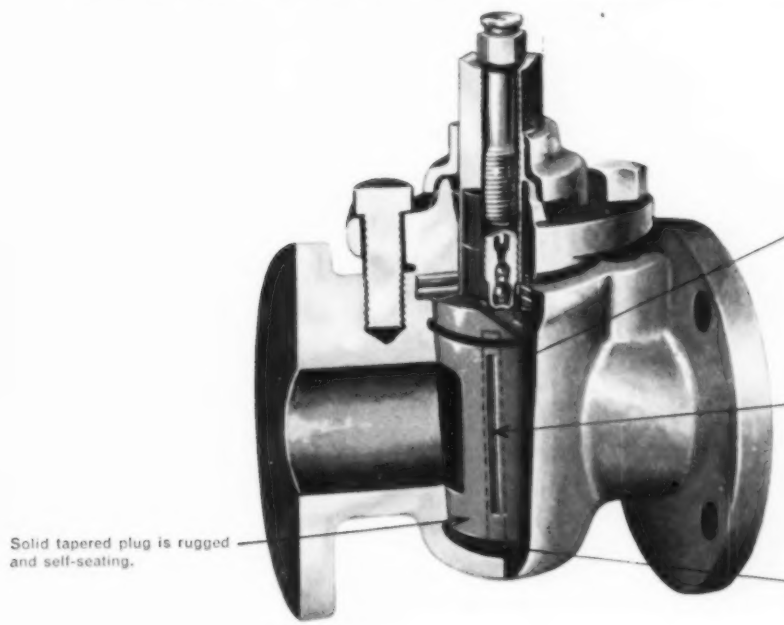
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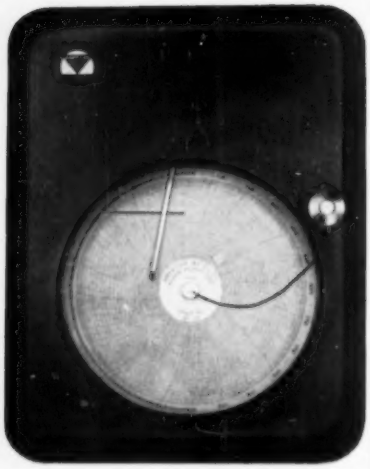

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Are Electronic Brains Useful to You?

Instrument Society meeting will go into wide range of computer control of processing and other problems

IT MAY BE THE TOUGHEST PROBLEM of the century — how to put electronic "brains" to work for the welfare of all mankind. The subject will be attacked by some of the best scientific and engineering minds in the country in Chicago September 21-25, 1959 when the Instrument Society of America has its yearly conclave of experts on electronic brains for everything from automated industries to moon rockets.

The meeting will be the 14th to be conducted annually by the society since its organization soon after World War II. It will be held, as in other years, in conjunction with an international exhibit of instrumentation and automation equipment.

The ISA Conference and Exhibit, known collectively as the "instrumentation show" this year will depict progress throughout the world in efforts to conquer space and make industries more productive.

Recognizing mastery of the use of electronic brains to be a major problem in science and industry, conference planners have scheduled 54 technical papers related to the subject.

Regarding what answers these authorities may have for computer problems, this much may now be predicted:

1. *More human brainpower than ever before in ISA Conference and Exhibit history will be focused on the question of how, when and where man should use electronic brains, now that he has them.*
2. *Answers will have far greater significance for the future than the use of computers to pick money winners in the Kentucky Derby, however skeptical may be the nation's horseplayers on this point.*

As an indication of the speed of developments in electronic brains, Instrument Society officials have decided that at least 12 papers at conference technical sessions will be for the purpose of tutoring scientists and engineers on how best to employ computers to solve some of their problems. In many instances, papers at these sessions — to be known as computer clinics — will cover subject matter new even to recent engineering school graduates.

Technical sessions certain to attract major attention from the experts will be those dealing with the question of using computers in the control of industrial processes, since developments in this area rapidly are bringing many industries to the day of the automatic plant.

As often is the case with technical papers, much of the glamor and significance of developments they relate may be lost in the wording of titles and abstracts. For example, a paper entitled, "A New Approach to Control Valve Sizing," scarcely would be recognized as one of the most exciting of the conference, until it is realized that control valves are fundamental to the successful operation of many industries and that this paper reveals a method by which, through the use of computers, previous errors in measuring valve sizes may be reduced by more than 25 percent.

That, as one ISA conference program planner observed, is as though a bathtub manufacturer were to discover that he no longer needed to worry about occasionally producing one-and-a-half inch plugs for two-inch drains and could now rely on plugs — or valves — fitting his tub drains with uniform precision.

Greater emphasis than ever will be placed this year on participation in the ISA conference by scientists from Great Britain and Continental Europe. Dr. C. J. D. M. Verhagen of Delft, The Netherlands, is scheduled to make a keynote address at one of the major conference sessions. Dr. Verhagen, professor-director of Laboratorium Voor Technische Physica Der Technische Hogeseschool, also will take part in conference sessions devoted exclusively to presentations by authorities from overseas.

The International Federation for Automatic Control, of which Dr. Verhagen is a representative, has accepted ISA's invitation to be one of the cooperating technical societies at the conference. ★ ★ ★

Continued From June Issue

Changes Indicated in International Operations

Ernestine Adams

THE SCENE CHANGERS have been at work in world activities of the oil and gas industries. There is evidence of impatience with political clamps on economic improvement as represented by energy industries. There is a new comprehension of petroleum operations and their advantages.

Some strange agreements have come out pretzel-formed to skirt old prejudices. The end result must be the same — profit for oil companies and for nations or there is no progress.

In the first part of this review (June, 1959 issue) the many contracts and concessions in Argentina, Australia, and the Sahara of Algeria and Lybia were described.

One of the most intense exploration programs is in Pakistan, where the government provides 25 percent of exploration costs up to an agreed sum, and profits will be shared 50-50.

Spain's new oil code is much more realistic and new capital is being attracted to seek oil and gas there. Both Pakistan and Spain have interesting petroleum potential.

It would be difficult to assess carefully the two regional assemblies on petroleum within the last year but they obviously gained wider understanding for the petroleum industry.

The symposium held in New Delhi, India, last December was sponsored by United Nations' Economic Commission for Asia and the Far East. The nations — Japan, Australia, New Zealand, Indonesia, India, Pakistan, Afghanistan, Burma, Thailand, Malaya, Singapore, British Borneo, Sarawak, Taiwan (Formosa), Vietnam, Laos, and the Philippines — present at the meeting delved into possibilities of greater oil and gas resources. Exploration programs have gained some in these regions but are still held back in many places by unfavorable political and economic climates.

At the meeting in Cairo, Egypt, in April of this year some erratic proposals were brought out but, on the whole, the observers attending found a frank exchange of views, a firmer understanding of what it takes to run the petroleum industry. This meeting was sponsored by the Oil Committee of the Arab League and attracted some 500 people from all over the world.

Below is the conclusion of our 12th Annual Round-Up of Petroleum Activities in individual nations and territories.

TWELFTH ANNUAL ROUND-UP OF WORLD OIL ACTIVITIES

EDITOR'S NOTE: Figures are average for 1958 unless otherwise stated.
R. C. — Crude refining capacity.
Runs — Crude runs to stills.
(?) — Indicates information slight.

MOZAMBIQUE

The old concession on which Mozambique Gulf Oil Company had drilled 5 wildcat tests in previous years was due to expire in 1958. During 1958, MOZGOC and Pan American International, acting jointly, negotiated a new contract with the government. A new concession issued jointly to these 2 companies was granted under Decree No. 41766 and went into effect on August 5, 1958, with a term of 40 years. It covers approximately 37,000 sq miles. Work under the new concession commenced shortly after January 1, 1959.

The Portuguese company SONAP is reported to have planned a refinery near Lourenco Marques, in the southern tip of Mozambique. Initial capacity would be 4000 b/d.

NETHERLANDS

Prod. 32,000 b/d **R. C. 349,000 b/d**
Runs 330,000 b/d

N. V. Nederlandse Aardolie Mij. (Royal Dutch/Shell-Jersey) only oil company engaged in searching for oil in the Netherlands, was able to conclude the past year with a notable success. As a result of systematic explorations 4 new oil deposits were found in the area between The Hague, Gouda and Dordrecht. Thus, the number of oilfields discovered in this area within 5 years, has been stepped up to 12. Within a very short time, Western Holland has developed into a new European oil province, in addition to the producing district on the Dutch-German border (Schoonebeek). With the help of prolific Schoonebeek in eastern Holland, the Netherlands produce about one-fourth domestic demand.

NAM has begun seismic surveys off the North Sea Coast in Southern Holland. These surveys are to assess potential of the offshore area.

The careful work of the NAM has conserved all finds in the country. Output increased about 6½ % in 1958 over 1957. Production improved steadily over the past 6 years, most of the increase coming from Western Holland.

Esso Netherlands is still building its 90,000 b/d refinery at Rotterdam. It will not be completed until 1960. Caltex is more than doubling its refinery at Pernis. It will have more than 100,000 b/d capacity when the expansion is completed. N. V. De Bataafsche Petroleum Mij has the largest of the 3 refineries with crude capacity of 300,000 b/d. All are near Rotterdam.

A 24-in. 187-mile crude oil pipeline is being laid from Rotterdam to the German Rhineland refineries at Godorf and Weseling. The company is N. V. Rotterdam-Rijn Pijpleiding Mij (Shell 40%, Caltex 40%, Gelsenberg and Mobil Oil 20%). Initial capacity of the line will be 150,000 b/d, although this can be increased to about 200,000 b/d by expanding pumping facilities.

These major investments by all the companies in the Netherlands will enlarge its operations considerably.

NETHERLANDS ANTILLES

R. C. 650,000 b/d
Runs 600,000 b/d

Aruba. Lago, Jersey Standard is building a fuel products unit at its refinery here. Its average runs in 1958 were 399,000 b/d. A complete revamping of the whole refinery is underway, with thermal reforming, thermal cracking, catalytic cracking, and alkylation being installed.

Curacao. Royal Dutch Shell is building a 20,000 b/d thermal reforming unit at its 210,000 b/d capacity plant.

NEW GUINEA (Neth)

Prod. 567 b/d

This discouraging country has taken over $100 million from the N. V. Nederl. Nieuw Guinee Petr. Mij (40% Royal Dutch/Shell, 40% Standard-

Vacuum, 20% Far Pacific Investment). The 3 small fields it has found have been producing less and less. There are now 38 wells in production.

In 1958, 2 rigs were operating, adding 2 oil producers, and drilling 3 dry holes. Geological crews spent 11 party months in the area, and geophysical crews worked 42 party months.

NEW ZEALAND

Prod. 43 b/d **R. C. 80 b/d**
Runs 33 b/d

Shell, BP, and Todd Oil Services, Ltd., were at the year's end rigging up to drill an exploration well in Taranaki, some 30 miles south southeast of the small New Plymouth field. A new large rig was imported for the project. This combine operates 2 drilling rigs and continues to carry out an exploration program despite discouraging results since it began in 1955. Six geological and 2 seismic crews are working. Shell handles operations on the West Coast in the Taranaki region and BP is responsible for operations on the East Coast in the Gisborne region.

Production comes from Maturoa in North Island.

Consumption of 37,000 b/d makes New Zealand among the top 3 petroleum products consuming nations in the world. Only the United States and Canada have higher per capita consumption.

NICARAGUA (C.A.)

A well drilled by J. Ray McDermott, Weatherford Oil, and Gulf Oil, 25 miles offshore in Nicaraguan waters, was abandoned as a dry hole. Occidental Petroleum acquired the only land concession, from Nicaragua Oil & Mineral Development Co., S.A.

The geological and geophysical work has been conducted for the past year-and-a-half by the latter. Occidental plans to start its first well soon with the $500,000 budgeted for drilling two 10,000-ft test wells this year.

NIGERIA

Prod. 5164 b/d

Shell-BP Petroleum Development Company of Nigeria, Ltd., has embarked on its fourth appraisal program, carried out at Bomu in the Eastern Region of Nigeria, where oil was struck in encouraging quantities in 1958.

So far, 2 oil wells have been completed, but many more will have to be drilled and considerable time may elapse before the commercial significance of the field can be determined. Unlike most of the Delta areas, the Bomu structure is on flat well-cultivated country, 12 miles south of Afam oilfield and a little more than 20 miles southeast of Port Harcourt, present terminal being used for export of Nigerian crude.

The company's first drilling program was carried out at Akata, also in the Eastern Region, where the first discovery of oil was made in 1953. Seven appraisal wells were drilled — 2 were abandoned due to technical difficulties; 2 encountered some gas, but none found oil.

Then came the discovery of oil in Oloibiri in 1956. Again hopes were raised, and this time prospects appeared much brighter. But results of subsequent drilling and test production proved rather disappointing. First, the confirmation wells drilled to define the boundaries of the field showed that accumulation was much smaller than originally expected and, secondly, many production troubles were experienced. Among these were the serious problems of wax, sand and water being encountered in the wells which adversely affected the rate of production.

For those reasons, the drilling program, after completion of 16 wells (11 of which are oil wells) has been suspended. Indications are that factors affecting accumulation in this field are unusually complex, and it appears that production operations will also be so. It is therefore obvious that more experience of actual production operations in Oloibiri must be gained to evaluate more thoroughly its economic aspects.

Meanwhile, detailed geological and seismic work is being undertaken on a comparatively large scale in the area with a view to determining whether drilling is justified at a later stage. Production from existing wells, however, is continuing at the maximum rate possible consistent with good oilfield practice, and at present Oloibiri is producing 3000 b/d.

Drilling in the Afam field is proceeding simultaneously with test production. In this field up to mid-February, 1959, 12 wells had been completed, only 6 productive. Results of test drilling and production have shown that in many respects Afam is almost as difficult as Oloibiri.

Up to the end of January 1959, Shell-BP had completed 33 exploration wells with a total footage of some 340,000 ft. Eleven of these encountered comparatively good shows of oil, including the 4 — Akata, Oloibiri, Afam and Bomu — which have warranted drilling programs. Possibilities of the other 7 shows, including 3 in the swamps of the Delta, still have to be investigated.

Of the 33 exploration wells, 14 were completed in 1958 alone, 5 of which encountered oil in encouraging quantities. During the year, the number of drilling rigs was increased from 6 to 8, including a Lake Maracaibo-type drilling barge. As a result of these new rigs and an improvement in drilling techniques the rate of drilling has improved.

Two pipelines were constructed — a 30-mile 6-in. line from Afam to Port Harcourt and a 65-mile 10-in. line from Oloibiri to the same terminal, which has 2 temporary storage tanks with capacities of 50,000 bbl and 40,000 bbl, respectively. Projects earmarked for 1959 include laying a pipeline from the Bomu area to Afam.

Intensive geological and geophysical operations have been carried out in the company's concession areas, which are spread out mostly in the southern parts of the country. Altogether, 25 core-holes covering a total footage of nearly 60,000 ft have been drilled for geological information. In the past, gravimetric surveys were carried out in addition to seismic surveys, but now only the former are active.

There are at present 7 seismic parties at work — 4 in the eastern region and 3 in the west.

By the end of 1958 Shell-BP had invested some $117 million in Nigeria, out of which $41 million was spent in 1958 alone. The total quantity of oil exported during that year amounted to 1,885,000 bbl.

What, then, is the future of Nigeria as an oil-producing country and what are the chances of the big investment being rewarded adequately? These are the questions which the company is trying to answer. It is already certain that geological conditions in Nigeria are in no way comparable with those in countries with prolific production such as the Middle East or Venezuela; nevertheless, Shell-BP is devoting all resources at its disposal in an attempt to ensure that Nigeria takes her place among the significant oil-producing countries of the world.

Only other concession is held by Mobil Exploration Nigeria, which had 1 geological crew and 2 geophysical crews operating on its 4000 sq mile exploration permit in coastal zone of the western region. Continued exploration activity is anticipated.

Consumption in this country is about 8000 b/d. These products are shipped in and the crude oil is exported. There is no refining capacity.

NORWAY

R. C. 2500 b/d
Runs 1600 b/d

Jersey Standard is building the country's first major refinery here at a cost of $30 million. It will be built at Slagenstangen on the Oslo Fjord and will have a capacity of 40,000 b/d of Middle Eastern crude oil.

Consumption in Norway runs 61,300

b/d, only slightly above what it was in 1957. Crude oil is imported for the A/S Norske Esso plant at Valloy per Tonsberg as there is no production in the country.

OMAN-MUSCAT

(AND DHOFAR)

The discovery made by Cities Service at Marmul in the Dhofar province of the Sultanate of Muscat and Oman, has proved disappointing. Output has declined and the well cannot be considered commercial. In 1958 Dhofar-Cities Service (Richfield has a 50 percent interest in the 32,000 sq mile concession) had 3 rigs operating in the area, and drilled 10 wells, all dry.

Petroleum Development (Oman), Ltd., an associate of Iraq Petroleum holds a concession over the whole of the Sultanate except for the province of Dhofar, where it relinquished its rights in 1951. It has done some exploration work over its concession area and began drilling Ghaba No. 1 early in 1958. This is the second test by the company. At last report it was below 12,000 ft.

PAKISTAN

Prod. 6200 b/d **R. C. 7500 b/d**
Gas 36,878 mcf/d **Runs 6800 b/d**

West Pakistan. Exploratory work continued without cessation throughout 1958 and 7 companies are active in the search for fresh oilfields though none has been found so far.

A summary of the exploration effort believed to have been conducted by operators in the area includes 38 party months of geological surveys, 48 of seismic surveys and 28 of gravity surveys.

Total exploratory wells abandoned during the year was 11. Four wells were still drilling at the end of the year.

Pakistan Petroleum Ltd. (Burmah Oil) continued exploratory work in the West wing of the country in 1958 with geological work in the field and 3 rigs active for part of the year.

The company's Bannh No. 1 well, west of Sibi, was abandoned at 13,001 ft in April. Adhi No. 2, a joint PPL-Pakistan Oilfields Ltd. (Attock Oil) well in the Punjab district spudded in during November 1957, was abandoned at 3780 ft. Jacobabad No. 1, eight miles northwest of the town, was abandoned at 3264 ft; Jacobabad No. 2 was abandoned at 5814 ft; Mazarani No. 1 drilled by PPL and Hunt International 80 miles west of Khairpur, was drilling at 9945 feet at the end of the year.

Pakistan Oilfields Ltd. did some geological fieldwork at the beginning and end of the year. Karsal Well No. 2, a joint POL-PPL well, was 12,677 ft deep at the end of the year. A previous well in this area, Karsal No. 1, produced small quantities of oil. POL's Kallar Kahar test was abandoned at 6145 ft after reaching a total depth of 7130. Traces of heavy oil were found.

Pakistan Shell Oil continued exploratory work in West Pakistan with geological and geophysical parties in the field and one rig active for most of the year. A well at Giandari (northeast of PPL's Sui gas field) was drilled to 12,007 ft without finding commercial production. Karampur No. 1, 56 miles southeast of Multan, was spudded in at the end of the year.

Tidewater, Skelly and Kewanee (33⅓% each) in March, 1958, signed a concession agreement with the government to explore two areas totaling 10,000 sq miles in West Pakistan.

During 1958 Tidewater's exploratory efforts consisted of surface geological evaluation of some of the more prominent structures in the Karachi Block (2500 sq miles). Geophysical work is now in progress in this area. A geological camp has recently been established near Turbat and field studies of Tidewater's Baluchistan Block (7500 sq miles) are in progress.

Sun Oil Company has two gravity meter crews and one seismograph crew in West Pakistan and it is also making geological studies of its concession.

Hunt International Petroleum Company the first 6 months had a seismograph crew and 2 gravity crews working and then 1 gravity party for the last 6 months of 1958. They drilled 4 dry holes.

Another exploration program is becarried out by Stanvac. Geological crews worked for 20 party months and geophysical crews for 40 party months during the year. One drilling rig is in operation and 2 wells were drilled.

Pakistan's oil legislation has succeeded in encouraging exploration. The government, in the case of Stanvac, Hunt, Shell, Sun, and Tidewater, provides 25 percent of exploration costs up to an agreed sum. Profits will be shared on a 50-50 basis.

Production from Attock Oil's Khauk, Dhulian, and Joya Mair field and PPL and Attock's Balkascar field, in the Punjab, totalled 2,271,379 U. S. barrels.

A profitable project in West Pakistan is the development of PPL's Sui gas field. At the end of the year output averaged 46,300 mcf/d.

A 16-in. pipeline from the Sui field to Multan, 334 miles to the north, was completed in 1958. In 1955 a 16-in. pipe from the gas field south to Karachi was built.

Talks are proceeding with the government on a 30,000 b/d refinery to be built near Karachi by a consortium of Burmah Oil, Shell, Stanvac, and Caltex.

East Pakistan. Operations in this wing of the country, which is separated by 1000 miles of Indian territory from West Pakistan, included 34 party months of seismic survey work, 3 months of gravity survey and 2 months of geological field survey. Further drilling was in hand or contemplated during the year.

Pakistan Petroleum resumed a reflection seismograph survey in November 1958 when weather conditions were again suitable for field work.

PPL's Lalmai No. 1 well, spudded-in during September 1957, was abandoned in February 1958 as a dry hole at 9813 ft, having been sidetracked at 9220 ft after a fishing job. At the end of the year the company was preparing to drill at Chhatak, 25 miles northwest of Sylhet.

Pak-Stanvac had a reflection seismic survey in progress. No geological field studies were undertaken. At the year's end plans were in plan for the drilling of the operator's first test well in East Pakistan.

Pakistan-Shell continued gravity survey work in East Pakistan and seismic work. An offshore reflection seismograph survey with the use of an aircraft was also conducted giving a total of about 10 seismic party months. In addition some geological field studies were undertaken.

Consumption in both East and West Pakistan now runs around 39,000 b/d, most of which is imported in the form of products.

PANAMA

Champlin Oil and Refining have moved a drilling barge to Chiriqui

S. A. Year Book Out

"The 1959 Oil Directory of Key Personnel in South America and Year Book," published by E. Ospina-Racines, has been released. There are an estimated 2500 names and titles of top personnel in oil companies, drilling contracting firms, equipment and supply companies. The directory has been prepared with the cooperation of governments and companies in the petroleum industry.

The 16 countries of South and Central America are included. Data concerns addresses, cables, airmail, telephone, warehouses, etc. There are also complete tables of 1958 oil operations by country. Maps are: South American Oil Fields and Sedimentary Basins; Land Holdings in Bolivia; Drilling Operations in Brazil; Oil Fields and Drilling in Colombia.

The directory, which is $23 for one copy, can be ordered from E. Ospina-Racines, Apartado Aereo 49-45, Bogota, Colombia.

Lagoon on the Caribbean Coast where it drilled its first test in 1958.

Most of the country of Panama has been blanketed by concessions and exploration is in progress.

Two refineries are planned. Panama Refining Company has scheduled a 70,000 b/d plant for late 1961 completion at Los Minas Bay. Panama Refining and Petrochemical Company (John W. Shaheen and Eugene Du Pont) plan a 55,000 b/d plant at Colon. Foster Wheeler has the contract.

PAPUA

(EAST NEW GUINEA)

This is the Australian territory on the east side of New Guinea Island. Two companies are exploring here — Australasian Petroleum Company Pty. and Island Exploration Company Pty., Ltd. Both continued exploration drilling throughout the year of 1958, completing 4 holes. Lean gas in appreciable quantities was encountered in pre-Tertiary sediments in the island. The program for 1959 includes drilling 2 deviated holes from Puri No. 1, perhaps 2 other holes in the vicinity and making further geological and seismic surveys.

PARAGUAY

Union Oil Company explored the Chaco region right after World War II, and in 5 years spent $7½ million before relinquishing its concession. Now a number of U. S. companies and one Brazilian firm are exploring the area. Pure Oil and Associates (Gulf, Williams Bros., Sinclair, Tidewater) drilled 2 dry holes and is now drilling a third.

Consumption runs around 1500 to 1600 b/d and products are shipped in to supply this. An affiliate of Jersey Standard proposes to construct a refinery in Asuncion to provide for consumption. It will cost about $3 million.

PERU

Prod. 51,320 b/d **R. C. 46,800 b/d**
Gas 112,000 mcf/d **Runs 44,215 b/d**

The first major effort to explore the offshore petroleum possibilities of the continental shelf in the Pacific, west of the long productive mainland concessions of the International Petroleum Company and Lobitos in northwestern Peru, is now underway by Peruvian Pacific Petroleum Company (Cities Service-Richfield). Peruvian Pacific has chartered from Richfield the 683-ton *"Rincon,"* a floating drilling barge and the 86-ton work vessel *"El Barquero."* Drilling operations began in March 1959.

Cia. Peruana de Petroleo "El Oriente," S. A. has brought in 10 producing wells in its Maquia field, east of Contamana, a port on the Ucayali River. The Maquia field occupies a small section of the "Sol" No. 1, No. 2 and No. 3 concessions and is the first producing field to be developed in Peru since the Ganso Azul field was discovered in 1938. Ganso Azul is on the Pachitea River, a tributary of the Ucayali, south of Contamana.

From the Maquia wells, a 5-mile, 5-in. pipeline has been built to Puerto Oriente on the Ucayali, near Contamana, with storage tanks for 20,000 bbl of crude. Arrangements are being made for barge shipments later this year, at the rate of 700 b/d to the new Brazilian refinery at Manaus on the Amazon.

Participating with "El Oriente" in the development of the Maquia field and in exploration operations on the company's concessions in the Ucayali basin generally, are three of the largest oil producers in Western Germany — Gewerkschaft Elwerath, Deutsche Erdoel A.G. and Wintershall A.G.

Consumption in Peru is 41,600 b/d. It has exports on balance; 4390 b/d of products are shipped in. Exports are 5935 b/d crude oil and 8425 b/d products.

Largest refinery is the Talara plant of International Petroleum. Peru's first petrochemical plant on Callao Bay, just north of the port, has gone into operation.

In a statement issued in New York International Petroleum reported that earnings in Peru, where the company has invested more than $180 million, were further depressed by the growing volume of products sold in the domestic market at the low level of officially controlled prices. Because of the factors mentioned, profits of International in Peru from domestic sales and exports were less than 2% on the amount invested.

PHILIPPINES

R. C. 25,000 b/d
Runs 24,083 b/d

Active exploration is being conducted in the Philippines on 157 exploration concessions covering 30,000 sq miles, granted to 26 oil companies.

Gas was found in Ipil No. 1 by Stanvac in Luzon Island, at a depth of 7260 ft. The company is at present drilling Ipil No. 2.

Some 22 geological crews and 3 geophysical crews were working in the islands in 1958. Two drilling rigs drilled 4 dry holes.

Only refinery at present is the Caltex plant at Batangas. Stanvac is constructing a 21,000 b/d refinery in Bataan province, at an estimated cost of $40 million. It is due for completion in 1961. Two other projects are scheduled. One is Shell which expects to build a 25,000 b/d refinery in the Luzon area, and the other a refinery in which Philippino interests will hold the majority stock and Gulf Oil will have a 40% interest.

Consumption was 44,088 b/d in 1958.

POLAND

Prod. 4000 b/d? **R. C. 15,000 b/d?**
Runs 12,000 b/d?

Russia and Poland have signed a new agreement providing increased technical aid for developing the Polish oil and gas industries between 1959 and 1964.

The pact provides for Russian delivery of "the newest Soviet equipment for exploring oil and gas deposits, deep drilling tools, and hoists." It also agrees to a wider exchange of petroleum geologists and production personnel between the 2 countries.

Crude oil has been found in commercial quantities in the Mielec district of southern Poland, the first discovery in this part of the country.

Part of the deal with the USSR is a refinery to be started in 1960 near Konin. It will process about 40,000 b/d initially and capacity will be doubled by 1966.

Consumption is estimated at around 36,000 b/d.

PORTUGAL

R. C. 26,000 b/d
Runs 22,400 b/d

Mobil Exploration Portugal operates one rig in Portugal in association with Portuguese-Swedish interests.

Only refinery is that of SACOR at Cabo Ruivo.

Consumption is about 22,000 b/d and an expansion is planned for the oil refining capacity of the SACOR plant to 30,000 b/d. Consumption has risen steadily for many years and is expected to go on at a rate of about 8% increase per year.

PORTUGUESE GUINEA

Esso Exploration and the Portuguese government are associated in a firm that will explore a 17,000 sq mile concession in Portuguese Guinea, on the West Africa Coast. A test is being drilled in Senegal by Societe des Petroles du Senegal (BP and French interests) on the northern border. Esso expects to spend $7 million over the next 5 years.

PUERTO RICO

R. C. 75,500 b/d
Runs 63,000 b/d

Following changes in early 1958 in Puerto Rico's oil and gas laws, several permits were approved by the government. Maritime Oil Company, A. B. Fraser of Kingston, Jamaica, Cataract Mining and others hold prospecting permits in Puerto Rico.

Courtesy Aramco

MOHAMED N. REDA is one of the 8669 Saudi Arab employees of the Arabian American Oil Company who has risen to skilled or semiskilled jobs. He is assigned to Aramco's engineering department. Today 73 percent of the company's Saudi Arab employees are on the skilled or semiskilled levels, in comparison with 37 percent only five years ago.

The 2 refineries are Commonwealth Oil Company's at Guayanilla and Caribbean Refining at San Juan. By an active expansion program now under way, the Commonwealth refinery will have a capacity of 67,000 b/d.

Application to build a pipeline from near the Guayanilla refinery to San Juan, Puerto Rico, was made by U. S. interests.

QATAR

Prod. 176,000 b/d **R. C. 600 b/d**
Runs 600 b/d

Production rose a spectacular 24% in 1958 over 1957. The land concession is held by Qatar Petroleum Company, an associate of IPC.

A marine concession, beyond territorial waters, was granted to Superior Oil about 1950 and was surrendered the following year without drilling.

In 1952 Shell acquired a marine concession covering 10,000 sq miles. A big drilling platform operated by Shell was wrecked owing to a sudden swell. Another platform is under construction in the Netherlands.

Qatar Petroleum had one rig drilling most of the year in the only field, Dukhan, on the west side of the peninsula. The three wells drilled are producers.

Oil refining is confined to a little plant at Umm Said.

ROMANIA

Prod. 230,000 b/d **R. C. 220,000 b/d**
Gas 500 m³cf/d **Runs 170,000 b/d**

The Romanian oil industry is in the doldrums, admitted even by reports from the Communist satellite. Gas production seems to be the only thing making headway. This is due largely to pipeline construction. Three new gas lines from the Transylvanian fields are: (1) to northeastern Hungary, completed in December 1958; (2) to Hunedoara in Western Romania, under construction; and (3) to Moldova province in northeastern Romania, under construction. The line completed to northeastern Hungary is 227 miles long and has a capacity of over 7 billion cu ft of gas annually. The line to Moldova province will serve cities near the mouth of the Danube River.

Some 54 rigs are in operation.

SAUDI ARABIA

Prod. 1,015,029 b/d **R. C. 189,000 b/d**
Runs 168,119 b/d

Arabian American Oil Company's production of crude oil during 1958 exceeded an average of 1,000,000 b/d for the first time over the period of a full year. Aramco had 192 producing oil wells at the end of the year.

At the end of the year, 4 seismograph and 4 structure-drill crews were carrying on exploration work. Six of these crews were operating in the Rub' al-Khali, the "Empty Quarter" in the southern part of Saudi Arabia.

Four drilling rigs were operating on December 31, 1958. Twenty-three deep wells were completed during the year; 15 were oil wells. Most of the rest were injection wells for pressure maintenance.

An exploratory well, Khurais 1, 90 miles northeast of Riyadh, Saudi Arabia's capital, was completed for production from the Arab-D member of the Arab Zone, the principal producing zone in Aramco's onshore fields. Two additional wells to define the limits of the Khurais field were completed in 1958 and a fourth was drilling at the end of the year.

Another exploratory well, Manifa 1, 8 miles offshore in the Persian Gulf, resulted in the discovery of Aramco's second offshore field. This was the first well to have discovered oil production in Aramco's area of operations from the Yamama formation, identified as Lower Cretaceous, which lies above the Arab Zone. A second producing well in the Manifa field also was completed during the year.

Proved remaining recoverable reserves were estimated at approximately 36.7 billion bbl at the end of 1958.

Construction of a $30 million gas-injection project for the 'Ain Dar area of the Ghawar field was completed early in 1959. This project is designed to compress and put back into the oil reservoir approximately 210,000 mcf/d. It will serve the dual function of conserving presently unused gases and of assisting in maintaining reservoir pressure. Completion of the 'Ain Dar plant at Abqaiq will result in the conservation and industrial use of 66% of the gas produced in Saudi Arabia.

Also under construction was an alkylation plant, to make possible the manufacture of about 2000 b/d of aviation gasoline at the Ras Tanura refinery.

Aramco distributes 8000 b/d of products.

SICILY

Prod. 30,420 b/d **R. C. 60,000 b/d**
Runs 58,000 b/d

AGIP (ENI) is finding the Gela field difficult to handle. The oil has a 7 API gravity and sulfur base. Gela produces about 4400 b/d. Offshore exploration will begin near Gela by ENI this year.

Largest field in Sicily is the Gulf Oil Ragusa field, which in 1958 produced 22,920 b/d. Gulf has 3 drilling rigs in the country and drilled 20 wells, 14 of which are producing.

Sicily has a separate oil code for oil exploration and production, but the Italian Constitutional Court has ruled that refinery projects require the con-

sent of the Italian government and that the Sicilian regional government is not authorized to grant permits.

During 1958 RASIOM Raffinerie Siciliane Olii Minerali, the only refinery, treated 58,000 b/d. Part of the crude (15,000 b/d) was delivered to Augusta from Ragusa through a 62-mile pipeline. Another 7500 b/d came from Gela. The remainder was imported from Middle East and Egypt.

During the current year RASIOM plans to treat about 80,000 b/d and in the future 100,000 b/d. A new topping plant was added in 1958.

RASIOM completed the pipeline and gas line system (40 miles) through which it can supply fuel oil, fuel gas and light virgin naphtha for cracking to many industries.

SOMALILAND (British)

Stanvac has one drilling rig in the country, which spudded in at the last of the year. It will drill a deep test in this British East African protectorate on a rugged desert drill site about 30 air miles southeast of the Port of Berbera on the Gulf of Aden.

Conorada also has a rig in the country where the company was exploring the 33 million acres covered by its prospecting license.

SOMALILAND (Italian)

Sinclair Somal (Sinclair 50%, Amerada, Continental and Ohio 50%) completed and abandoned a third deep test well on its 66,000-sq mile concession and a fourth deep test is now drilling.

Stanvac has a geological crew working on its new 10,300-sq mile concession in the west of the country, extending about 200 miles along the Ethiopian frontier. The permit is for 3 years and may be extended 3 times for 3 years each.

SPAIN

R. C. 150,000 b/d
Runs 130,000 b/d

A new law governing exploration and development of oil and gas became effective December 29, 1958. The law represents a radical departure from official policy as laid down in the law of November 24, 1939, for the defense of the industry. Not only may foreign oil companies organize Spanish companies in which they may own up to 100% of the capital if they so desire, but such foreign companies may themselves be registered in Spain and operate there. The latter provision will permit American companies to take advantage of consolidated tax return provisions and the depletion allowances of the U. S. income tax laws.

During 1958 VALDEBRO continued an active program of geological, geophysical and drilling activity in most of the potential petroliferous areas of the peninsula. Four wells were abandoned at depths ranging from 3800 to 7200 ft. Three additional wells were drilling as the year ended. One of these, 15 miles north of Gibralter, had reached a depth of 11,454 ft by the end of the year. The other 2 are in northern Spain—one near Pamplona in Navarra Province was drilling at a depth of 6135 ft, and the other, 5 miles east of Petrosa in Burgos Province, drilling at 328 ft. Shows of oil and gas have been observed in 2 of the wells now drilling.

During the year another rig and seismic crew were added to the program so that there were 3 drilling rigs and 4 seismic crews in operations during the last half of the year.

The exploration agreement between the Institute of National Industries and the American participants, originally entered into in 1952, has been extended. This VALDEBRO group is headed by General American Oil Company of Texas and includes DeGolyer and MacNaughton, Delta Drilling, Lion Oil, E. E. Fogelson and others. DeGolyer and MacNaughton furnishes technologists both in Madrid and Dallas, and Delta supervises the drilling activities. Spanish personnel is used extensively throughout the organization.

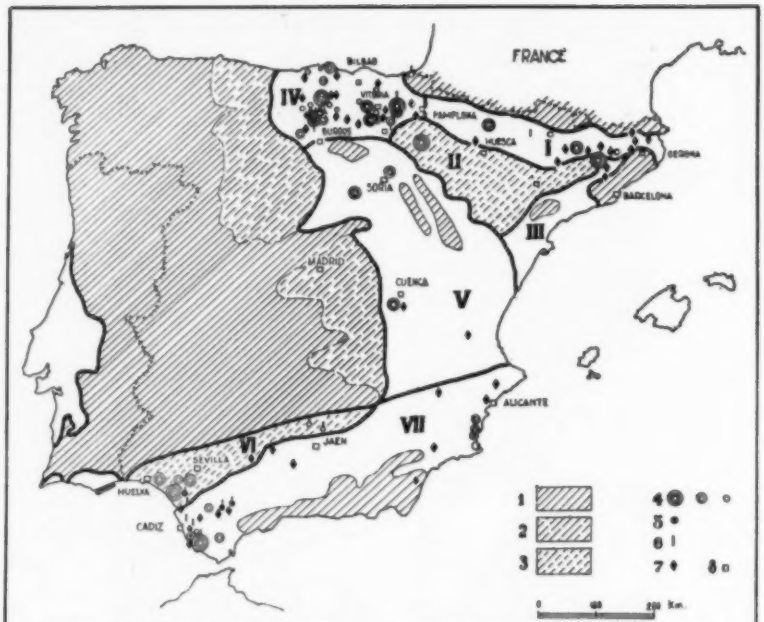
The new petroleum law reserves 8½ million acres to INI, of which 1,900,000 acres will be dedicated to VALDEBRO.

Deutsche Schachtbau-und Tiefbohrgesellschaft has acquired a share in Compania Petrolifera Iberica. Petrolifera has begun exploratory activities in its concessions in the provinces of Alava, Burgos, and Navarra. Deutsche Schachtbau's participation is said to amount to 25%. Schachtbau is to drill wells and supply equipment and technical advice under a service contract.

Consumption of petroleum products indicates the astounding progress of Spain in recent years. In 1958 demand rose 12% over 1957 to 120,000 b/d.

On its oil exploration in Spain, CIEPSA, a wholly owned subsidiary of CEPSA, cooperates with the German concern, C. Deilmann.

Eight drilling rigs in 1958 drilled 11



1. Hercynian basement of the Meseta.
2. Hercynian basement of the Meseta recovered with thick continental tertiary deposits.
3. Hercynian basement of the basins of the Ebro and Guadalquivir recovered with deep marine and continental tertiary deposits.
4. Wells drilled; every circle shows 1000 m. (3281 ft) of depth.
5. Wells drilled where oil has been found.
6. Gas.
7. Indications of oil.
8. Towns.

In blank: Mesozoic and low tertiary deposits of the Alpine mountains.

I. Pyrenees
II. Basin of the Ebro
III. Catalonian mountains
IV. Cantabric zone
V. Iberian Chain
VI. Basin of the Guadalquivir
VII. Betic Chains

Courtesy American Chamber of Commerce Magazine, Madrid, Spain.

SPAIN — Its Geology and Drilling Operations.

wells; 4 had gas shows but none commercial production.

Expansion of the Teneriffe and Cartagena refineries is being considered; also possible installation of a third refinery on the North Atlantic Coast of Spain.

SUMATRA (Indonesia)

(SEE INDONESIA)

Prod. 315,220 b/d **R. C. 175,000 b/d**
Runs 166,000 b/d

Of 3 companies that are in Sumatra, Caltex has about 2 million acres. Its Minas field, brought into production in 1952, has provided most of the increase in Indonesian production. Another Caltex field, Duri, has been connected by a 30-in. pipeline to a shipping terminal at Dumai on the east coast of Sumatra. The field Bekasap will also be joined to this pipeline and terminal. Caltex produces about 149,000 b/d from the Central Sumatra area.

Stanvac has a 1.9 million-acre concession. One of its best fields, Lirik, in Central Sumatra, has a specially heated 88-mile, 8-in. pipeline to the Siak River. Stanvac's total production is 75,000 b/d from Lirik and other fields.

Shell who also holds concessions in Sumatra has had no access to its north Sumatra fields since 1942, when they were occupied by the Japanese. Its Sumatra fields produce more than 90,000 b/d.

SUDAN

The government of Sudan has recently issued a petroleum resources act establishing rules and regulations for development and use of petroleum resources in Sudan. There are several drawbacks to this — one of the main ones being that after 10 years the owner of a lease may have to increase royalty upon decision of a government committee. Maximum is equivalent to 70% of net profits. If a company is allowed to enjoy only 30% profit in a new and untried area, there will be few interested.

Consumption has been increasing rapidly in Sudan. Last year it rose to 8000 b/d, a 14% increase over 1957.

SYRIA

Only development is in the Karatchok field in northeast Syria. Menhall Prospecting and Exploitation Company (Atlantic Refining and Portsmouth Steel, the other 2 participants) discovered Karatchok No. 1 in 1956 in Upper Cretaceous limestone at a depth of around 6500 ft. In 1957 Karatchok No. 2 was completed as a producer.

Drilling activities in 1958 included: Karatchok No. 3, a stratigraphic test, bottomed at 3984 ft without reaching the Upper Cretaceous pay zone; No. 4 and 5, development producers, and No. 6, suspended at 2278 ft because Menhall exploration permits were cancelled.

Negotiations concerning the status of these permits are presently under way. The Menhall group had no drilling operations in progress at the end of 1958. Reports are that the state's General Petroleum Authority expects to develop the field.

Some drilling was undertaken in 1958 by Societe des Petroles Concordia, a subsidiary of Deutsche Erdol-A. G. Concordia had two seismic crews operating in 1958. DEA also has an exploration license covering the area across the border in Turkey.

The Syrian government has an agreement with the Soviet for technicians to explore and develop oil resources.

The government refinery at Homs, being built by a Czechoslovakian firm, will be completed this year.

Consumption was cut in 1958 because of closure of the frontier with Lebanon, source of supplies. Syria, now in the Union of Arab Republics with Egypt, consumes about 16,000 b/d products, all imported.

SWEDEN

R. C. 52,000 b/d
Runs 43,000 b/d

Sweden has three refineries, one of them for shale, which is a 2000 b/d plant. The petroleum refineries are at Nynasham and at Goteburg, both locally owned.

Consumption in 1958 reached approximately 176,000 b/d inland consumption, and about 206,000 b/d counting bunker consumption.

SWITZERLAND

Jersey Standard and a group of local Swiss companies decided to terminate their agreement to explore in the Canton of Berne. Exploration permit was granted pending a change in the law. On behalf of S. A. des Hydrocarbures, Lausanne, in which Gewerkschaft Elwerath has a share of 50%, Elwerath is drilling an exploratory well of approximately 5600 ft in the Swiss canton of Waadt near the village of Moudon (north of Lausanne).

Proposal for a refinery has been given up because the Swiss government laid an import duty on crude oil. There are no refineries in Switzerland at this time.

TANGANYIKA

BP-Shell has 2 drilling rigs in this East African country, which completed 5 shallow holes, all dry. A deep test was drilling at the end of the year. During 1958 there were 2 geological crews and 1 geophysical crew continuing the search.

Consumption is about 4250 b/d.

THAILAND (Siam)

Thailand Royal Department of Mines has drilled 30 wells with the 2 rigs at its disposal and now has 21 wells capable of producing oil. Two surface crews are still working.

Two refineries are being built — one is at Fang Chiang Mai, North Thailand, with a 1000 b/d capacity. This one is expected to go into operation before the end of this year. At Bangkok the Fuji-Car Manufacturing Company is building a refinery of 5000 b/d capacity.

TIMOR (Portuguese)

Tradewinds Exploration, Inc., has exercised an option to drill a 15,000-ft test on the Island of Timor, off Darwin, Australia, earning the oil and gas exploration company a 50% interest in a 7000-sq mile concession covering the Portuguese portion of the island that lies in a trend with the major producing fields of Sumatra and Java. The concession is owned by Timor Oil Ltd., an Australian firm.

TRINIDAD

Prod. 102,343 b/d **R. C. 186,000 b/d**
Gas 200 m³cf/d **Runs 165,000 b/d**

Operational activity of the oil industry in Trinidad may be summarized briefly by the following table of statistics, from which it will be seen that the total crude oil produced shows an increase of 11.0% over the previous year.

	1958	*1957*
Total crude oil prod. (bbl)	37,355,059	34,063,947
Avg. number of drilling strings	32	29
Wells completed	295	314
Producers (oil or gas)	256	282
Footage drilled	1,365,129	1,322,483

Dominion Oil has been drilling exploratory holes in the Gulf of Paria from a floating barge since September 1957. The method utilizes an anchored barge with a 12-ft center well and specially developed submarine blowout equipment. Since beginning operations numerous improvements have been made, the main features being the 130-ft reinforced derrick which allows 10,000 ft of 4½-in. drill pipe to be set back. Two wells have been drilled to below 10,500 ft and 2 strings of 7-in. casing set to approximately 9000 ft, which seems to prove the feasibility of the method.

Trinidad Petroleum Development Company maintained 7 rigs throughout the year. During 1958 the first of 2 T-32 diesel outfits was introduced. In 1959 2 of 4 steam rigs will be replaced by these rigs.

Premier Consolidated Oilfields, Ltd., engaged a contract rig for 2 months to drill 11 shallow wells in the Fyzabad

field, all of which were completed as producers.

Apex operated 3 rigs in the Fyzabad field and 1 deep appraisal rig in the Erin basin. Buenos Aires C-3/651 was drilled to 13,276 ft. The drill pipe stuck at 13,207 ft and at the end of the year side-tracking operations were in progress due to stuck drill pipe.

Shell operated 3 strings, drilling 202,125 ft, of which 128,646 ft was on further development drilling in Point Fortin and Los Bajos, Penal and Inniss. Mechanical difficulties resulted in the abandonment of one Point Fortin development well and the shallower completion of another.

Development drilling was maintained by Texaco on all fields with continued emphasis on the Palo Seco Grande Ravine area where 3 rigs were in operation. Good results were also obtained in the Trinity field. The first marine well (ABM-1) was drilled from a multi-well platform north of Brighton field and by year end 2 additional deviated marine wells had been successfully completed from the same platform.

A total of 17½ party months of geological field work and 4 party months of geophysical field work were carried out during the year in Trinidad.

Total 1958 refining capacity in Trinidad was equivalent to 186,000 b/d and the actual average throughout was 165,000 b/d as compared with 138,000 b/d in the previous year. Toward the end of the year Texaco Trinidad Inc. announced that it was planning extensive construction work on its refinery to increase its refining throughput to approximately 250,000 b/d for a cost of some $30 to $40 million.

Consumption is estimated at 38,000 b/d.

TRUCIAL COAST

(SHAIKHDOM OF ABU DHABI)

Three wells were drilled by Petroleum Development (Trucial Coast) where traces of oil were found. All were deep wells (below 12,000 ft).

Abu Dhabi Marine Areas (BP ⅔ and Cie Compagnie Francaise des Petroles ⅓) drilled offshore from a platform that was brought from Germany last year. An encouraging find was made in this test and a second one is drilling.

TUNISIA

Gas 595 mcf/d

An oil prospecting concession has been granted by the Tunisian Government to Societa Olii Minerali of Palermo (subsidiary of Rimrock International), which at present holds a search permit in Sicily. With a total area of roughly 6000 sq miles, the concession covers part of Cape Bon, the islands of Djerba and Kerkenna and the area around Gabes.

Conorada (Conoco, Amerada and Ohio) has two geological parties in the country starting exploration of its 11,000-sq mile concession in south Tunisia. No geophysical work or drilling has yet been done.

First company to explore Tunisia was SEREPT—owned 70% by French interests (mainly the state) and 30% by Tunisian Government. The company has three drilling rigs operating in its exploration concessions, which cover about 6000 sq miles. SEREPT drilled 5 wells, all dry. It has some gas production from its Cape Bon field, averaging 595 mcf/d in 1958.

An agreement has been reached by a subsidiary of CREPS and the Tunisian Government for a 16-in. pipeline to be built from the Edjele, Tiguentourine and Zarzaitine fields in Algeria, across Tunisia to the Mediterranean near Gabes.

TURKEY

Prod. 7000 b/d **R. C. 6250 b/d**
Runs 5500 b/d

Exploratory activity has been carried out in Turkey by a number of licensed operators in 1958. Most recent entry of the 20 or more companies already in the field was Pan-Am Land and Oil Royalty, which has acquired almost a million acres in 3 different districts. This is an independent Dallas, Texas, firm organized to develop foreign petroleum interests. The president is a former DeGolyer and MacNaughton vice president.

Deutsche Erdoel A. G. (DEA), a German firm, has been granted exploration licenses in 8 areas, which combined are nearly a million acres.

A report near the close of the year indicated that American Overseas Petroleum (Standard of California and Texaco) discovered oil at Kahta, 17 miles southeast of Adiyaman, Gaziantep district, Petroleum Zone VI.

Atlantic, Tidewater and Texaco found gas in one test and are drilling another. A drilling program is scheduled by this group.

Not much progress has been made on the refinery that is supposed to be erected by Socony, Shell, Caltex, and BP. Plans are for a 65,000 b/d refinery. So far the only refinery is a domestic-owned one at Batman.

In 1958, 32 surface crews worked for the various companies and 22 geophysical crews. There were 12 drilling rigs in the country and 23 wells were drilled, of which 12 were producers. This brings to 47 the number of wells now producing.

Consumption averaged 31,665 b/d in 1958, according to Emin Iplikci, president of Petroleum Administration.

TURKS ISLAND

Standard of California, which has the only exploratory rights in and around this island in the Bahamas, had one combined magnetic and gravity crew for about 2 months on the island in 1958.

UNION OF SOUTH AFRICA

R. C. 24,300 b/d
Runs 24,300 b/d

Stanvac has the only refinery operating here and it runs at full capacity. The refinery was expanded last year and is adding capacity of 1500 b/d crude this year.

Shell Oil's proposal to build a refinery was rejected, and Caltex has made application to construct a $65 million refinery at Durban.

Consumption of petroleum products dropped some this year. Inland consumption averaged 79,200 b/d and bunker, 12,200 b/d; 24,000 b/d of this was imported in crude oil and 69,000 b/d in products. Inland consumption rose about 5½%.

We have not included SASOL oil from coal plants.

UNITED KINGDOM

Prod. 1575 b/d **R. C. 778,400 b/d**
Gas 68 mcf/d **Runs 524,000 b/d**

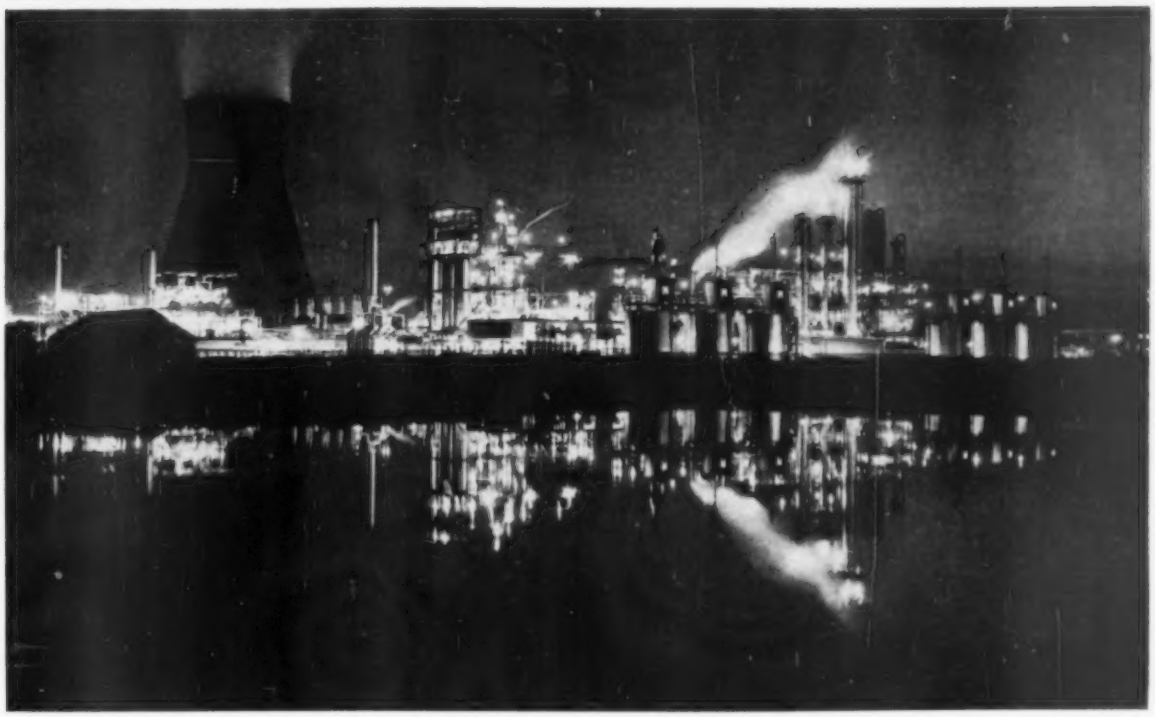
British Petroleum, which has the only concession in the United Kingdom, celebrates its 50th anniversary this year with a long and successful history behind it. Output in the United Kingdom is the smallest of almost any of its projects. Here the company keeps 2 surface crews and 3 geophysical crews operating. In 1958 with 6 drilling rigs, 27 wells were drilled, only 4 of them are producers. These make a total of 230 wells which now produce oil or gas. Reserves of oil are thought to be about 5½ million bbl.

The long standing Caltex proposal for a refinery on the Solent, at Warsash opposite Fawley, in Southampton (the Esso refinery site) was postponed by the company because it was unable to announce a date for construction.

The Shell Mex and BP Company sought, in November 1958, Parliamentary powers to build a pipeline from Walton-on-Thames to London Airport —a distance of about 8 miles—to supply aviation fuels. The main need is for jet fuel; demand at the airport is expected to treble in the next 5 years and cannot be supplied by road without adding seriously to traffic congestion at the airport approaches.

At Milford Haven, West Wales, work began on Esso's $47 million project for an oil refinery with an initial crude throughput capacity of 100,000 b/d, and marine installations capable of handling simultaneously two 100,000-ton tankers.

Expansion of BP's Kent refinery was



Courtesy British Petroleum

NIGHT VIEW of British Hydrocarbon Chemicals, Ltd., plant at Grangemouth, Scotland, in which British Petroleum has a 50 percent interest. The plant is adjacent to BP's Grangemouth refinery.

completed late in the year. As well as raising the crude oil processing capacity to 200,000 b/d, this project also provided for the production of aviation gasoline. Expansion work at Grangemouth to raise capacity to 62,000 b/d continued during the year.

Consumption averaged 640,000 b/d in 1958, including refinery fuel. Some 688,000 b/d of crude oil was imported and 226,000 b/d of oil products (including bunkers). This was a big jump in consumption over 1957, owing to restrictions imposed during the Suez Crisis. Last year's total consumption showed a gain of 26% in inland consumption.

UNITED STATES

Prod. 6,709,000 b/d R. C. 9,955,000 b/d
Gas 3,147 m³cf/d Runs 7,606,000 b/d

The year 1958 was a slow one for the U. S. oil industry. Reserves did improve, however, and productive capacity reached 10 million b/d (IPAA figures).

Some 48,000 wells were drilled. A new depth record of 25,340 ft was made by Phillips Petroleum in Pecos County, Texas. It was a dry hole.

Capital expenditures in 1959 will be higher than in 1958. U. S. petroleum companies spent $6.8 billion in 1958* and plan $7.4 billion capital outlays in 1959. This does not include the gas transmission and distribution industries.

New oil trunk pipelines constructed in the United States last year totaled 4127 miles, comprising 2460 miles of crude oil lines, at a cost of $127.5 million, and 1667 miles of products lines at a cost of $88 million, according to the U. S. Committee for Oil Pipelines.

During 1958, 15,300 miles of new gathering, transmission and distribution pipelines were laid bringing total gasline mileage to 564,100 miles. Capital expenditures this year by the gas transmission and distribution industry — 97% on natural gas facilities — are expected to total between $1.7 billion and $1.8 billion.

Sales of natural gas by U. S. public utilities last year increased by 3% to an estimated 77.3 billion therms.

Domestic demand averaged 9,066,900 b/d, according to Bureau of Mines, 2% up from 1957.

U.S. PROVED RESERVES AND PRODUCTION, 1958
(Oil in million bbl; natural gas in billion cu ft)

	Total additions	Prod.	Estimated reserves at end of year
Crude oil ...	2,608	2,373	30,536
Gas liquids	858	342	6,204
Natural gas ..	19,000	11,485[1]	254,142[2]

Source: American Petroleum Institute and American Gas Association.

[1]Net production, i.e., exclusive of gas injected into producing reservoirs.

[2]Including gas held in underground storage (end-1958, 1,740 billion cu ft).

URUGUAY

ANCAP, state-owned monopoly in this country, has one drilling rig in operation and drilled 6 dry holes in 1958. ANCAP owns the only refinery in the country, which has a capacity of 27,000 b/d and is running at full capacity. It is being expanded by an added 28,000 b/d. Contract for construction was awarded M. W. Kellogg Company. Work is expected to take about 5 years.

Consumption in Uruguay is estimated at 24,655 b/d. Crude for the refinery comes from Venezuela and Chile, but the government now has an exchange agreement with Russia for 1 million bbl of crude.

USSR

Prod. 2,260,000 b/d? R. C. 2,400,000 b/d?
Gas 2,900 m³cf/d? Runs 2,300,000 b/d?

Latest issue of the magazine Neftyanoe Khoziaistvo (Oil Economy) says the USSR had 644 exploratory oil and gas geophysical crews (including 330 seismic) in 1957 and 438 geophysical crews in established oil and gas fields.

Based on plans to increase the number of geophysical parties 2.5 times by 1965, it would seem reasonable to es-

*"1958 Revises Industry's Pattern," The Petroleum Engineer, May 1959, Page A-21.

timate that Russia had around 1300 crews in 1958, including both exploratory and non-exploratory parties. It is known that the number of seismic parties jumped from 330 in 1957 to 440 in 1958.

Scattered reports indicate about 2200 new oil wells were put into production in 1958, bringing total oil producers to 34,000 at the end of the year. The Plan stated 1000 rigs would be in operation.

Oil production rose 15% in 1958 over 1957. Soviet sources gave 17% increase in oil output in 1957 over 1956. This gives a good idea of the sharp upturn in the petroleum industry in the USSR.

Only in recent years has the Soviet made any effort to develop natural gas resources and progress has been rapid. Proven reserves total 35 trillion cu ft.

The following pipelines being constructed provide an indication of the increase of production and distribution planned for the future.

Soviet pipelines being constructed

CRUDE:
Gorky-Yaroslavl
Gorky-Ryazan-Moscow
Ishimbai-Orsk
Romashkino-Gorky
Tuimazy-Omsk-Irkutsk

PRODUCTS:
Omsk-Novosibirsk (completed February 1959)
Kuibyshev-Penza-Bryansk
Ufa-Omsk (second line)

GAS:
Baku (Karadag field)-Tbilisi
Baku (Karadag field)-Erevan
Berezovo-Sverdlovsk
Bukhara (Jarkak field)-Samarkand-Tashkent-Frunze-Alma Ata
Bukhara (Gazli field)-Chelyabinsk
Bukhara (Gazli field)-Sverdlovsk
Dashava-Minsk-Leningrad
Dzhebol-Perm
Bugulma-Izhevsk
Krasnoarmeisk (Saratov fields)-Chelyabinsk
Kohtla Jarve-Tallin (shale gas)
Kuibyshev-Melekess
Moscow (Serpukhov)-Leningrad
Minsk-Vilnius-Riga
Mubarek-Samarkand-Tashkent
Mubarek-Samarkand-Stalinabad
Izbaskent-Fergana-Leninabad-Ursatevskaya
Poltava-Kremenchug
Rostov-Krasnodar-Tuapse-Sochi
Krasnodar-Kerch-Sevastopol
Saratov-Penza-Gorky-Ivanovo-Yaroslavl-Cherepovets
Shebelinka-Dnepropetrovsk-Krivoi Rog-Nikolayev-Odessa-Kishinev
Shebelinka-Kursk-Orel-Bryansk
Stavropol-Moscow (Second Line)
Stavropol-Grozny
Stavropol-Makeyevka-Slavyansk

Application to export large diameter pipe to the Soviet was turned down early this year for the third time by U. S. Government. A license to export 12,227 short tons of 28 to 30-in. line pipe valued at $2.5 million was rejected on the grounds of national interest.

Refining capacity is being enlarged. Under construction now are refineries at: Angarsk, Omsk, Pavlodar, Fergana, Kazan, Polotsk, Yaroslvl, Ryazan, Krasnoyarsk, and Irkutsk. The latter two will satisfy 75% of the demand of Eastern Siberia. Crude will be shipped to them from the Tatar fields by pipeline.

Trade agreements indicate the Soviet export business will pick up again in 1959. Russia exported about 255,000 b/d in 1958 and a rise to 300,000 b/d is expected this year. About 10,000 b/d went to Finland and Austria, the same to Western Germany. Egypt took some 30,000 b/d, Western Europe 140,000 b/d, and the remainder in smaller volume to Iceland, Denmark, Morocco, India, and South American countries.

☆ ☆ ☆

A RUSSIAN GEOLOGICAL exploration team in the eastern Ukraine is being hailed by the Soviet press for, of all things, failure to reach its goal.

While drilling for coal in the Pavlograd area, the geologists brought in a gas well rated at over 3,500,000 cu ft daily. Fortunately, the misdirected drill bit scrupulously followed the new Communist Party line, which calls for greater emphasis on gas production at the expense of solid fuels.

☆ ☆ ☆

Some 170 to 173 billion rubles ($42 to $44 billion) are budgeted for capital investment in the new Seven Year Plan. In 1958 $1 billion was reported to be invested, 15% more for oil development than in 1957 and 48% more for gas industry investment.

VENEZUELA

Prod. 2,604,840 b/d **R. C. 780,000 b/d**
Gas 351 m³cf/d **Runs 690,000 b/d**

Average production in Venezuela was down only 6% despite U. S. restrictions against imports. Reserves also improved and at the end of the year were more than 17 billion bbl of oil, or about 10.2% above 1957. At the end of the year the oil industry was hit by a government decree, which called for a rise in income taxes retroactive to January 1, 1958. This decree was made by the outgoing provisional government although Betancourt, the new president, had already declared he would seek higher oil revenues for the state.

The political situation has not yet settled down and it is difficult to see the path of the oil industry in the future. Betancourt is said to be opposed to nationalization, but he insists that the state should have a greater voice in determining the course of the national industry. He is opposed to granting further concessions, but is prepared to make contracts with foreign oil companies on the same basis as the Argentine government has done.

Venezuela's natural gas reserves were estimated at 32.5 trillion cu ft at the end of 1957.

About 1150 wells were drilled during the year by 108 rigs.

Gulf Oil is expanding its Puerto La Cruz refinery by 60,000 b/d, which will double its crude capacity.

Venezuelan 1958 Production

Companies	Daily Average
Creole	1,071,104 b/d
Shell	703,697 b/d
Meneg	388,941 b/d
Socony	127,619 b/d
Mercedes	34,068 b/d
Texas	50,900 b/d
Richmond	75,217 b/d
Atlantic	27,941 b/d
Sinclair	61,533 b/d
Phillips	11,613 b/d
Talon	1,583 b/d
Caracas	27 b/d
Coro	62 b/d
Superior	26,327 b/d
Venez. Sun	12,103 b/d
San Jacinto	8,681 b/d
Signal	3,275 b/d
Pan Venez.	84 b/d
Continental	65 b/d
Totals	2,604,840 b/d

YEMEN

Yemen Development (U. S. interests) quit work in 1958 and voluntarily withdrew from the country. They were disturbed by 7 shiploads of arms that arrived from Czechoslovakia. There has been a report since that Czech geologists were doing some surface work in the interior.

YUGOSLAVIA

Prod. 8,300 b/d **R. C. 24,500 b/d**
Gas 96 mcf/d **Runs 22,100 b/d**

At least one new field has been reported in Yugoslavia in 1958. It is near Sisak in Croatia. The new discovery is expected to double production in the country.

A project for a new refinery of about 20,000 b/d capacity is being planned by the government. This might make the country self-sufficient in petroleum products for a time. At present consumption runs around 21,000 b/d.

ZANZIBAR

BP-Shell Petroleum Development of Zanzibar has the only concession here. This island is off Tanganyika in the Indian Ocean. One deep test was drilled in 1957 and no exploration work was reported in 1958. ★ ★ ★

Management Personals

▸ **N. C. Simpson,** departmental coordinator of Gulf Oil Corporation's domestic production department in Houston, was elected an administrative vice president. **I. G. Davis,** who has been administrative vice president and coordinator of Gulf's production department for the past year,

N. C. Simpson

I. G. Davis

was designated a senior vice president and will become a member of the company's executive group consisting of the president, executive vice president, and senior vice presidents. Simpson also will be chairman of the Production Council.

J. L. Lenker, vice president and a director of The British American Oil Company Ltd., is named a vice president of Gulf. **C. J. Guzzo,** who has been Gulf's vice president in charge of domestic marketing since 1954, is also designated a senior vice president.

F. C. Anderson and **R. W. French** were elected assistant comptrollers of Gulf Anderson served as departmental comptroller of the production department since September 1958, and will continue to be responsible for that department's accounting and related financial matters. French was recently appointed departmental comptroller of the crude oil department, and he will continue to handle accounting and related financial matters for that unit.

▸ **John L. Kent,** advertising and public relations manager of Datex Corporation, was appointed director of Western Technical Writing Institute. He has been the Institute's chief instructor since 1955. He is the founder and served as first president of the Technical Writing Improvement Society. Since 1946 he has been editor of two trade journals, several company magazines, and has had published over 3000 articles in national magazines.

James Touhey, sales analyst at Consolidated Electrodynamics Corporation, is new secretary and registrar. He served two years as national secretary of TWIS.

WTWI was founded in Pasadena in 1955 to help engineers and management people improve engineering writing.

▸ **Paul E. Taliaferro** was elected president and chief executive officer of Sunray Mid-Continent Oil Company. Taliaferro succeeds **W. C. Whaley,** president of the company for the past 7 years, who retired. Whaley will remain with Sunray, however, and was re-elected an officer as chairman of the executive committee. **C. H. Wright** was re-elected chairman, and **R. W. McDowell,** president of DX Sunray Oil Company, wholly-owned subsidiary, was re-elected vice chairman. All other officers were re-elected.

S. D. Breitweiser was elected executive vice president and **D. C. Wixson** was named administrative vice president for marketing of DX Sunray. Breitweiser's new position gives him active executive concern not only with the marketing activities but with its refining and pipeline operations also. Wixson's new assignment, under direction of the executive vice president, will give him administration coordinating responsibility with the new marketing council on sales policies, programs and procedures.

J. Floyd Ladd was elected treasurer of DX Sunray succeeding **B. P. (Bert) Lambert,** retired. Ladd will continue in his position as assistant treasurer of Sunray Mid-Continent. **Lewis Lacy** was elected secretary of DX Sunray and **L. Millard Gelvin,** assistant treasurer. Both Lacy and Gelvin hold similar posts with Sunray Mid-Continent.

▸ Colorado School of Mines has awarded its highest honor to **Geo. W. Clarke,** vice president, director and central division manager for Pan American Petroleum Corporation. He is one of five outstanding industrial leaders receiving the Distinguished Achievement Medal in 1959, which is equivalent to the honorary doctor of engineering degree.

▸ **S. M. Batterson** was elected president of Macmillan Petroleum Corporation. He succeeds **R. S. Macmillan,** founder and president for over 35 years, who is granted a leave of absence due to illness. Batterson, formerly vice president, has been with the corporation since its organization.

Donald H. McKee was elected a director, and is the managing partner of McKee & Co., investment bankers of Los Angeles, California.

▸ **J. W. Meehan,** executive vice president and general manager, was elected president of Derby Refining Company Division of Colorado, which was formerly operated as Derby Refining Company, a subsidiary of Colorado Oil and Gas Corporation. This follows similar action affecting Jas. P. Marsh Corporation, acquired December 1958 by Colorado. **A. D. Rose** continues as president of the Marsh Division, formerly president of Marsh Corporation.

All directors were reelected and they are: **J. S. Bowman, Joseph H. King, J. P. Moroney, W. E. Mueller, W. C. Norman, F. T. Parks, and W. G. Tierney.**

▸ **Robert L. Wood** of Midland, Texas, independent oil and gas producer and owner of the Basin Drilling Company and **G. D. Murdoch** of Los Angeles, California, manager of the underwriting and new business department of Dempsey-Tegeler & Company, were elected to the board of Ambassador Oil Corporation. Directors re-elected were **Conley Brooks, W. V. Coffey, C. Harrison Cooper, Guy Gadbois, John M. Hollern, Luther Hudson, F. Kirk Johnson, F. Kirk Johnson Jr.** and **Paul Keenan.**

▸ **John L. Kyser** was promoted to assistant manager of the supply and transportation department, Phillips Petroleum Company. He formerly served as assistant to the manager of that department.

George M. Brooner has become an assistant manager of the foreign sales and development department's patent licensing and market development division with offices in New York City. **E. E. Ratekin** was named the department's Tokyo, Japan, representative. Brooner was senior supervisor of the Perco division in the company's research and development department and Ratekin was assistant manager of natural gasoline and compound sales in the sales department.

▸ **Thomas C. Barger** was elected president of the Arabian American Oil Company. **Norman Hardy,** president since January 1958, was elected chairman of the board of directors to succeed **Fred A. Davies,** who retired. Hardy will continue as chief executive officer. **John Noble,** president of the Trans-Arabian Pipe Line Company, was elected to the board. Since 1958 Barger has been a vice president, assistant to the president and a director. Along with Hardy, he will continue to make his headquarters in Dhahran, Saudi Arabia.

T. C. Barger

Norman Hardy

John Noble

Shaikh Hafiz Wahba, (left below) Saudi Arabia's Ambassador-at-large to the Arab World, and **Shaikh Abdallah H. Tariki,** Saudi Arabia's director general of Petroleum and Mineral Affairs, were also

elected to the board of directors of Aramco. The new directors were added to the board in keeping with an agreement between the Saudi Arab Government and the company that the Government should have representation upon the board.

▸ **H. D. Armstrong** was elected treasurer of the Standard Oil Company of California, succeeding **H. C. Judd,** who retires after 28 years. Armstrong has been assistant to the chairman and is a director of various affiliated companies.

▸ Three key executives of Stekoll Petroleum Corporation named vice presidents are: **W. L. Hodges,** vice president, production; **Art Woerheide,** vice president, engineering, and **Ronald M. Hawkins,** vice president, finance. Hodges has been general field superintendent for production in Kansas, Texas, and, most recently, Canada. Woerheide was vice president and chief engineer for the Byrd Oil Company, joining Stekoll in 1957. Hawkins was with Dallas Rupe & Son, Dallas investment banking firm, joining Stekoll this spring.

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Personals

W. H. Barlow

G. F. Bish

C. A. Jackson

W. H. Barlow, Glenn F. Bish and **Charles A. Jackson** were elected to the board of The Ohio Oil Company. Barlow has served as manager of research since 1954 and manager of research and planning since February, 1959. Bish was elected a vice president of the company and appointed manager of domestic production in May 1959 and Jackson was elected treasurer in 1954.

Frederic H. Holmes, vice president in charge of Texaco Inc.'s research and technical department, became vice president in charge of the refining department. He succeeds **John S. Worden** who retired. **L. C. Kemp Jr.,** vice president in charge of the petrochemical department (domestic), succeeds Holmes. **William P. Gee,** vice president in charge of the petrochemical department (foreign), will also be in charge of petrochemicals—domestic.

Quincy V. Tuma was promoted to chief safety engineer. He succeeds **C. A. Miller,** retired.

Kraus Earhart, staff assistant, was named to replace Tuma as safety supervisor. Both will have headquarters in Houston.

Arthur W. Winter was elected vice president of Great Northern Oil Company. This will be in addition to his regular duties as assistant to the president. New directors are **H. B. Alspaugh,** Duncan, Oklahoma; **O. H. Ingram,** president, Ingram Oil and Refining Company; and **Fred C. Koch,** president, Rock Island Oil and Refining Company, Inc.

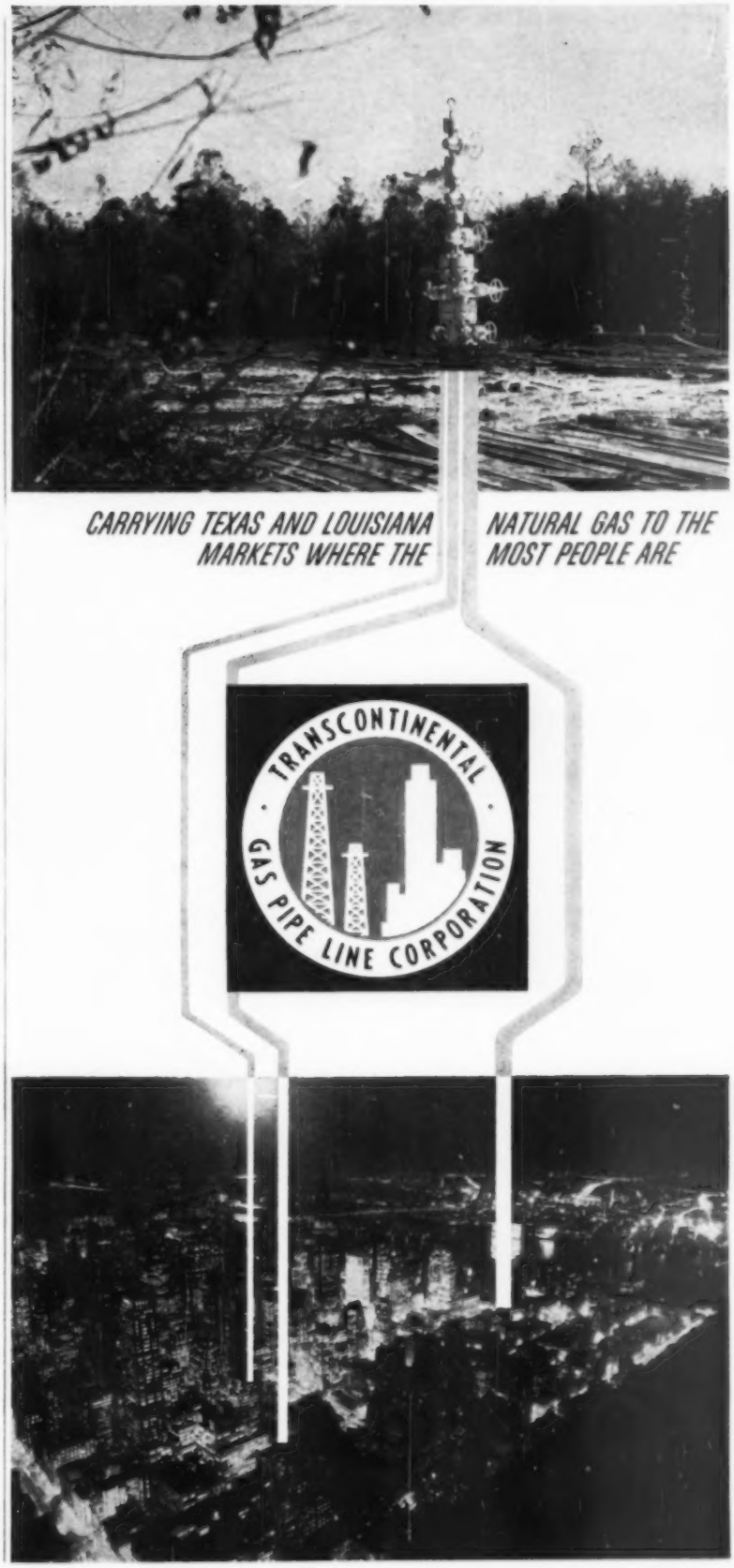
Robert C. Blum, president of Creole Explorations, Inc., was named a director of Petrosur Oil Corporation. Blum, a New Orleans attorney, has spent 20 years in Louisiana oil development.

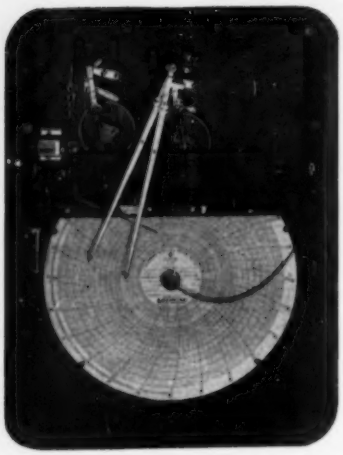
Richard C. McCurdy, president of Shell Chemical Corporation and a director of Shell Oil Company, was elected a member of the executive committee of Shell Oil.

W. O. Ham Jr. was promoted to general manager of Continental Oil Company's southwestern region, with headquarters at Fort Worth, Texas. Formerly coordinator of reserves purchases, he succeeds **G. T. Pearson,** who transferred to Calgary, Alberta, as president and director of Hudson's Bay Oil and Gas Company Ltd., a Conoco affiliate.

Warner Tyler, division marketing manager, was appointed to the newly created position of industrial relations manager for Conoco's northern region, with headquarters at Kansas City, Missouri.

Robert M. Youngs was elected chairman of the board and **Jack O. McCall** elected president of The Louisiana Land and Exploration Company.


CARRYING TEXAS AND LOUISIANA MARKETS WHERE THE
NATURAL GAS TO THE MOST PEOPLE ARE
TRANSCONTINENTAL
GAS PIPE LINE CORPORATION



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Personals

▸ **Dr. Benjamin R. Teare Jr.,** dean of the college of engineering and science at the Carnegie Institute of Technology, is president-elect of the American Society for Engineering Education. **Dr. Ralph G. Owens,** dean of engineering at the Illinois Institute of Technology, Chicago, is vice president for general and regional activities east of the Mississippi River and **Dr. Howard W. Barlow,** director of the Washington State Institute of Technology at Washington State University is vice president for general divisions and committees. **Wendel W. Burton,** employment manager for Minnesota Mining and Manufacturing Company, was named treasurer.

▸ **John Hawkinson,** vice president, treasurer and a director of the Central Life Assurance Company, was elected to the board of directors of Douglas Oil Company of California.

▸ **James A. Christensen** was appointed manager of the economic coordination department, Standard-Vacuum Oil Company. He succeeds **Willem Holst** who was recently elected to the board of directors. Christensen was assistant manager of that department. He had previously served 25 years with Esso Standard Oil Company in New Jersey, starting in 1928 in the laboratory at the Eagle Works in Jersey City.

▸ **Blair A. Hyde** has joined the advertising and sales promotion department of Richfield Oil Corporation at the headquarters office in Los Angeles.

▸ **Howard C. Kauffmann Jr.** was appointed manager of operations at Talara, Peru, for International Petroleum Company, Ltd. Kauffmann succeeds **Clarence Nielsen** who has accepted an assignment with the Iran Oil Operating Companies in which Jersey Standard has an interest. Succeeding Kauffmann is **William J. Nutt,** presently International's producing superintendent in Talara.

DEATHS

▸ **J. C. Lincoln,** 92, founder of the Lincoln Electric Company, died May 25. He had served as president of his company and later board chairman.

▸ **Alton F. Davis,** 69, vice president and secretary of the Lincoln Electric Company, died May 25.

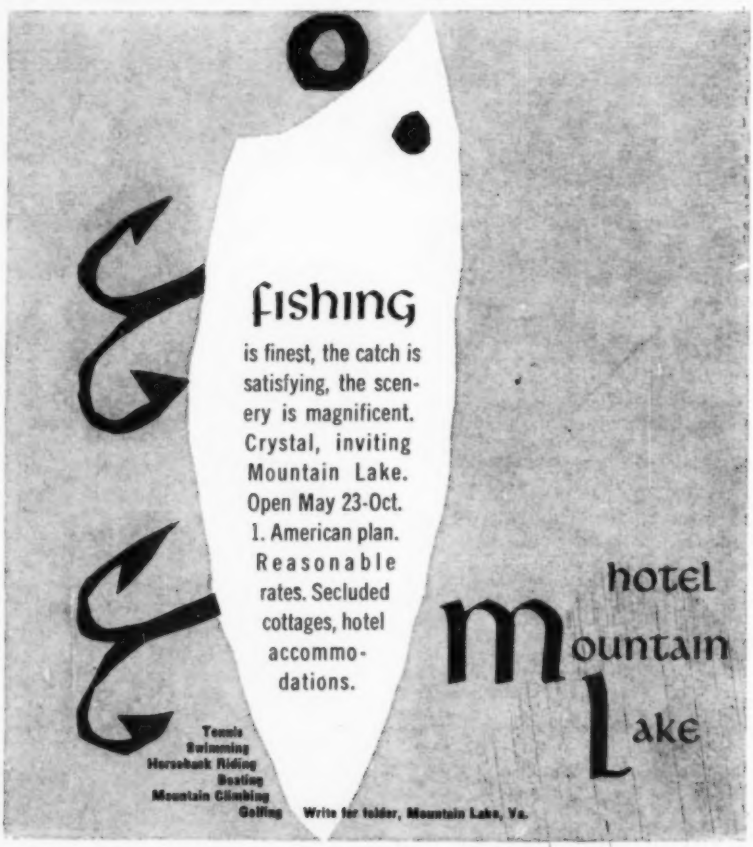
▸ **William P. O'Malley,** 60, executive vice president of Asiatic Petroleum Corporation, died May 8.

▸ **Harvey Ellis Davidson,** 55, chief engineer of Bethlehem Steel Company, Supply Division, died May 14, in a Tulsa hospital after a two-week illness.

▸ **Charles Penhaligen,** 57, auditor for The Dow Chemical Company and a member of the company's finance committee, died May 8 while on business at the Dow Texas division operations at Freeport.

▸ **Glen Crawford,** 62, advertising manager for the Leece-Neville Company, Cleveland, died April 14 in Pompano Beach, Florida.

▸ **Leon T. Mart,** chairman of the board of directors of The Marley Company, died May 17, following a heart attack. He formed the Marley organization in 1922 and was its president from that time until March 1959, when he became board chairman.



Laugh with Barney

"For 20 long and wonderful years," mused the gentleman at the bar, "my wife and I were deliriously happy."

"Then what happened?" asked the bartender.

"We met."

* * *

Men are most peculiar. A man who hadn't kissed his wife in five years shot a man who did.

* * *

MEDICINE AND LAW

I well remember a young legal friend of mine who went to a great gathering of the medical profession, trying to curry favor with them, which is a fault of some members of the legal profession. He tried to draw an analogy between the medical profession and the legal profession, and said: "I know not why I was invited here unless it be, there is some affinity between your great profession and mine, because I know that whenever I finish a case I say to myself, 'Now, have I left anything out?,' whereas the medical profession, at the end of a case, say, 'Have I left anything in?' "

* * *

KNEW WHAT TO DO

A friend of mine and I went to Coney Island, and we had a wonderful time. He knew what to see and what to avoid that wasn't worthwhile. The last attraction we visited was a shooting gallery, and here they had celluloid balls propelled by jets of water. The balls rose and fell and when they fell they fell out of sight. The idea was to hit them as you saw them. I shot all the cartridges in my rifle and didn't hit one of the balls. My friend picked up a gun, took careful aim, shot once and all the balls fell.

I said, "Bill, that's the most wonderful shooting I ever saw in my life. How on earth did you do it?" Bill replied, "I shot the fellow working the pump!"

It was just a matter of knowing what to do.

* * *

"In this country a man can have but one wife . . . This is called monotony."

ENGINEERS WANTED

BAKER OIL TOOLS, INC.

Desire Mechanical or Petroleum Engineers with oil field background, preferably with design experience.

Engineers presently employed by Oil Companies will be considered and employed only with the understanding and approval of their company.

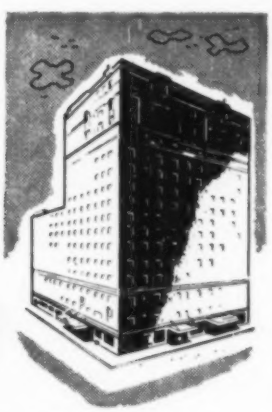
Please apply to Personnel Department in **Los Angeles,** Section "E," P. O. Box 2274, Terminal Annex, Los Angeles 54, California, or in **Houston,** Section "E," P. O. Box 3048, Houston 1, Texas.

William Way (left), manager of the International Petroleum Exposition is shown as he presented Henry Harnischfeger, president of Harnischfeger Corporation, the Special Centennial Award made in Tulsa on IPE grounds, marking the occasion of this Milwaukee manufacturer's 75th anniversary.

CHAPLAIN AND CONGRESS

The young fellow said to his dad: "Dad, why do they have a chaplain in Congress?" He said, "They have a chaplain there to pray." "Well, who does he pray for? Does he pray for the Congress?" He said, "Oh, no, he stands up and takes a look at the Congress, and then prays for the country!"

The Beautiful **Lamar**



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You'll like the extra luxuries and comforts which distinguish The Lamar . . . It's completely air-conditioned of course, with TV and radio in guest rooms. And food to please the most discriminating. Rates begin at $4.50. Garage Service.

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General Manager

IN THE HEART OF THE THEATRE & SHOPPING DISTRICT

Clean PIPELINES
Reclaim TANK BOTTOMS
with
BrakeSol
an exclusive
PARAFFIN TREATING CHEMICAL

BRAKESOL holds paraffin in suspension! Inject it into gathering lines and BRAKESOL keeps them free of paraffin.

BRAKESOL reclaims tank bottoms without taking tanks out of service! BRAKESOL chemically dissolves paraffin and puts it back in solution into the oil. Cost is nominal compared to savings.

BRAKESOL is safe to handle and will not harm your equipment. Let BRAKESOL eliminate your paraffin problems NOW!

FOR SERVICE . . . Contact your Supply Store or nearby BrakeSol Treating Engineer.

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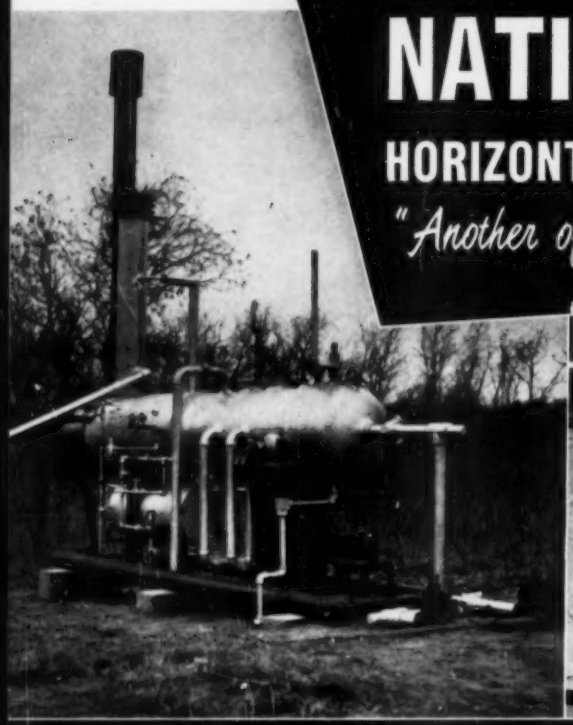
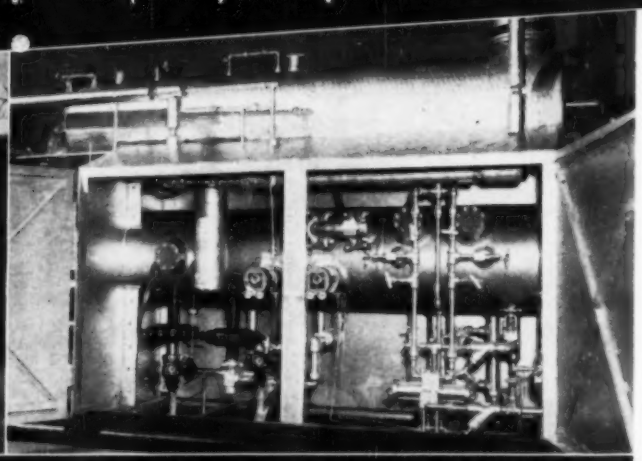
HORIZONTAL GLYCOL DEHYDRATION UNIT

"Another of Many Originals from National"



UNIT WITH INLET SCRUBBER ON STREAM NEAR OKLAHOMA CITY



WINTERIZED UNIT WITH 3-PHASE SEPARATOR INSTALLED NEAR FARMINGTON (Featuring a National Flame Arrestor)

PATENTED AND PATENTS PENDING

FEATURING:

- National Vari-Flo glycol trays
- National valves and controls
- Heat exchanger in skids
- Mist extractor on inlet to remove hydrocarbons before glycol contact
- Anti-down draft stack head
- National flame arrestor — eliminates all fire hazards
- Compactness
- Pre-piped
- Automatic
- Shop hook-up
- Shop insulated
- Ready for immediate service on delivery to your lease after well and pipeline tie-in
- National field service by trained engineers

National Vari-Flo horizontal glycol trays are more efficient than conventional trays now in use due to elimination of dead spots and non-channeling of glycol.

The glycol pump splits the flow into two equal streams of freshly concentrated glycol into the two horizontal trays.

The stainless steel removable Vari-Flo caps are a result of concentrated research in National's Laboratory. The caps are designed as a combination of the best features of the sieve tray and bubble cap but without the limitations of either.

The gas-glycol contact is automatically controlled according to the volume of gas going through the caps, thus permitting high contact efficiency at low as well as high flow rates.

Split flow contactor trays are "Another of Many Originals by National."

Dewpoint depressions have been obtained as high as 85° and 90° using New Hi-Dry Liquid Desiccant and depressions better than 75° using other glycols.

Depressions of 95° to 110° on four tray units using New Hi-Dry Liquid Desiccant.

Standard units in capacities of 2, 4, 6, 10, 15, 20, 30 and 40 MMCFD. Special sizes made to order.

Contact your nearest National Tank Company representative for more detailed information.

It's a National®

NATIONAL TANK COMPANY

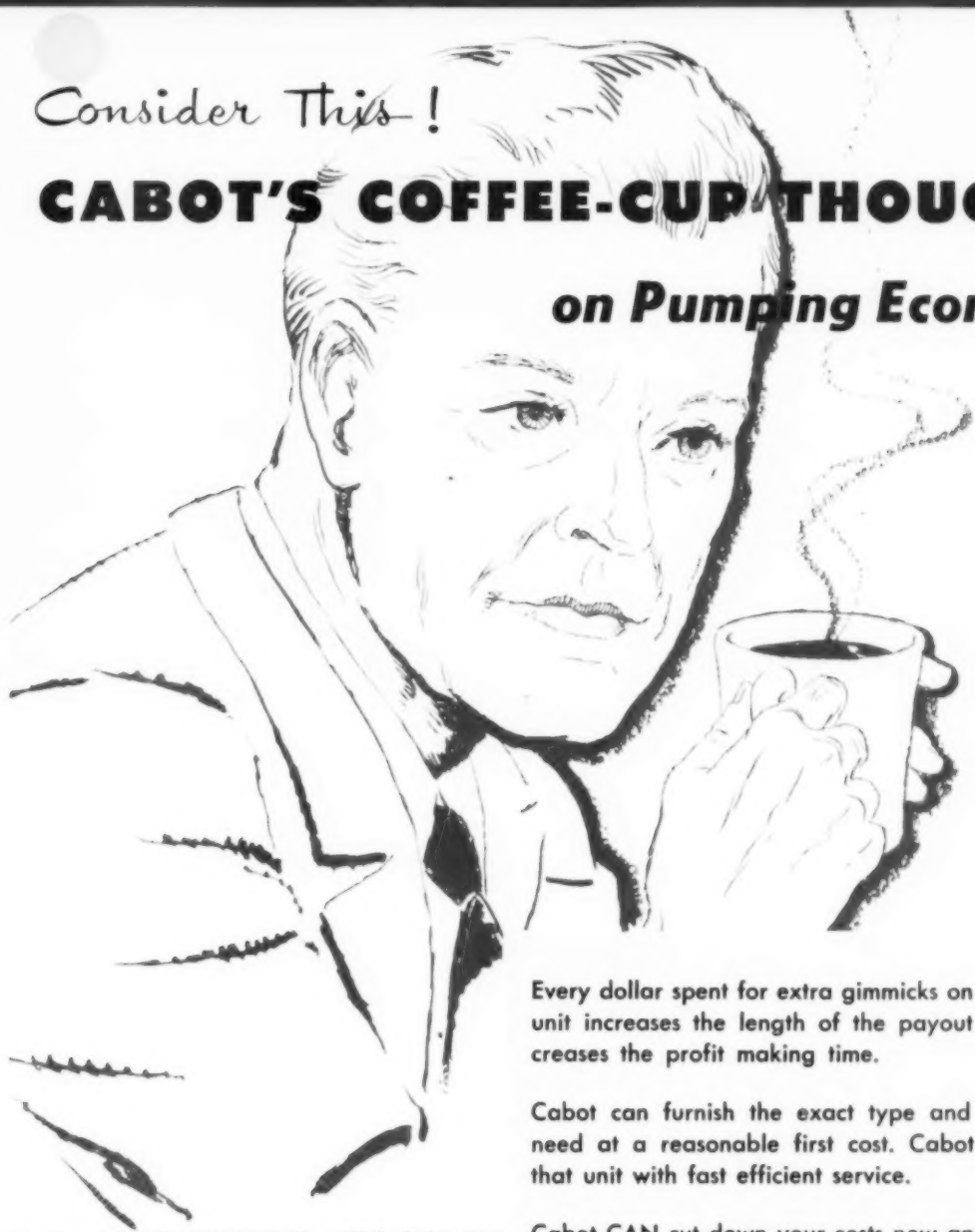
DRAWER 1710

TULSA, OKLAHOMA

Consider This!

CABOT'S COFFEE-CUP THOUGHTS

on Pumping Economics



Every dollar spent for extra gimmicks on your pumping unit increases the length of the payout time and decreases the profit making time.

Cabot can furnish the exact type and size unit you need at a reasonable first cost. Cabot can back up that unit with fast efficient service.

Cabot CAN cut down your costs now and in the future with down to earth "brass facts" assistance in planning your pumping operation.

A cost saver
Cabot Air-Balanced
Unit

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This new service assures that
all your mud material requirements
will be at your well — on time.

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5015

Of Things To Come . . . In Oil

BIG BUILDUP IN HELIUM EXTRACTION PLANT CONSTRUCTION is being given a boost by federal action, aimed at increasing U. S. helium reserves and production. First step in the drive is the opening of federal files to natural gas producers — and others — yielding basic information on helium-bearing natural gas characteristics and helium extraction by low-temperature processes. Files are located at Amarillo, Texas, and Washington, D. C. Interior Secretary Seaton hopes to generate industry interest to the extent that 12 new plants can be constructed.

ECONOMY OF PUMPING TRIPLE COMPLETIONS having been proved, pump manufacturers will be placing several installations in the field shortly. Both beam-type and hydraulic units have been installed, and manufacturers report work at "steady" pace equipping new triple pumpers. First triple-completed well was equipped with three beam-type units a few months ago in Texas Gulf Coast area. A new offshore installation of this type is among others being readied.

MISSISSIPPI'S CITRONELLE FIELD will move into a new phase of production shortly — secondary recovery by water injection. Leading the way toward unitizing a field waterflood project is Jett Drilling Company, et al, and Sterling Oil of Oklahoma, which recently acquired all Citronelle field properties of Gulf Oil Corporation and Gulf Refining Company. A Core Lab study for all Citronelle operators has been completed, and total recoverable reserves (by primary and secondary methods) near 1,000,000 bbl per well has been indicated.

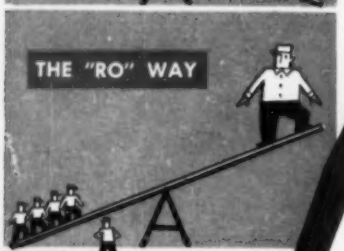
NEW CONCEPTS IN CRUDE OIL ORIGIN and composition may be divulged soon as a result of new techniques in gas chromatography analysis developed by Standard Oil (Indiana) and affiliates. J. C. Winters, analytical research scientist for the company, states that many rules of thumb to predict nature of crude are being overthrown as result of new information that is now becoming available. New technique permits complete analysis in 12 hours, contrasting to a project using former methods analyzing a single Oklahoma crude involving 300 man-years of study.

FEDERAL 'ACQUIRED LANDS' LEASING RULES are being altered to afford surface owners opportunity to "suggest lease stipulations and land safeguards." Bureau of Land Management has put proposed rules into writing and will soon include them in new regulations. The rules will make it necessary for the agency to notify surface owners (if they are in state and local government, institutional category) of an oil company's application for oil and gas lease.

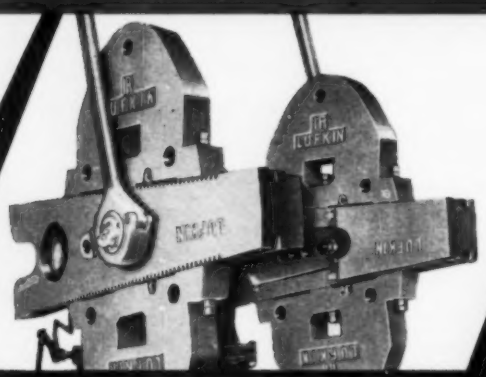
LUFKIN *Initiative*

SCORES AGAIN! . . . WITH THE NEW

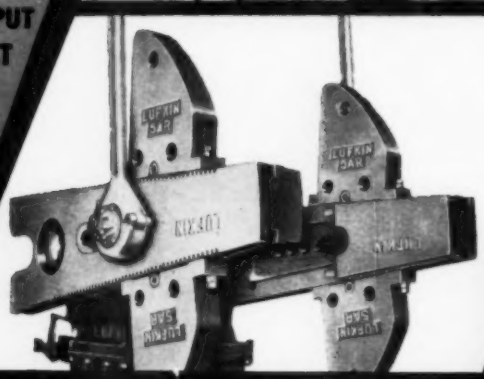
TROUT "RO" Series
COUNTERBALANCED CRANK*



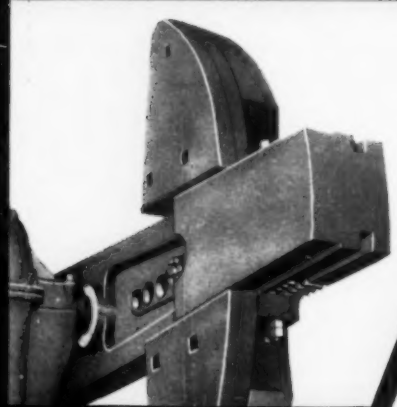
IT'S WHERE YOU PUT THE WEIGHT THAT GETS RESULTS.



Larger counterweights for above average requirements. Increased thickness at end of crank for extra counterbalance.



Smaller counterweights are interchangeable on the same cranks for reduced counterbalance requirements.

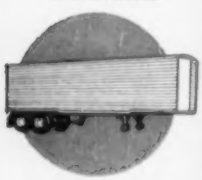


Extra space for thicker weights allows greater weight concentration at outer end of crank. Thick or thin auxiliary weights for greater counterbalance flexibility.

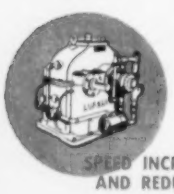
****OFFERS MORE EFFECTIVE COUNTERBALANCE FOR LESS WEIGHT***

PUMPING UNITS

GAS ENGINES



TRAILERS



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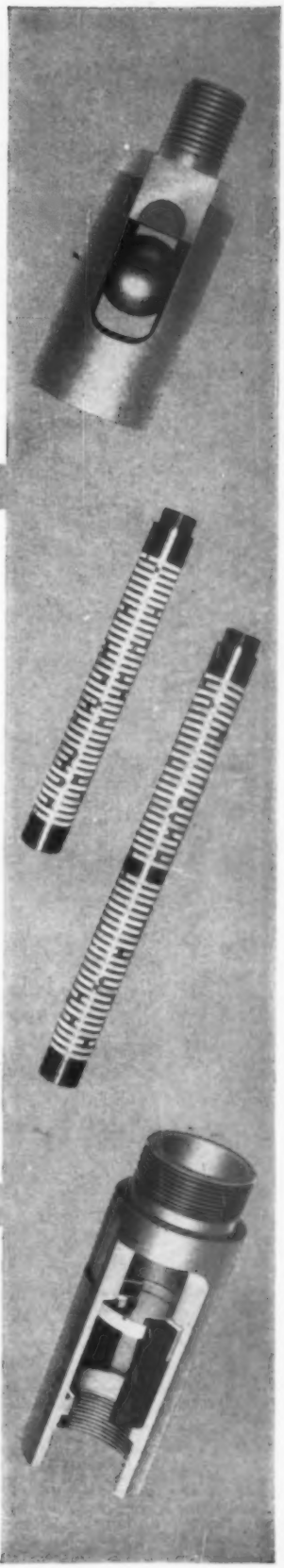

THE MARTIN PLUNGER is valuable to you because it can be used over and over by replacing only the rings — **plus** the bonus of longer tube life, due to slower wearing action of the resilient rings.

THE MARTIN RUBBER GUIDE CAGES are valuable to you because of their remarkable lasting qualities — **plus** the bonus of improved Ball & Seat life.

"Worth their weight in Gold" would not be an exaggeration, in some cases of extreme savings with these products.

IMMEDIATELY AVAILABLE . . . in all sizes and styles from our Tulsa plant. Sold by all supply companies and stocked at many points. Fully detailed in Composite Catalog, except for recent improvements mentioned below.

The Plungers illustrated are our new standardized 1½ ft. and 2 ft. lengths which screw together to make longer (Box & Pin, cage thread) plungers. You meet many requirements with just a few pieces. Readily interchangeable.

"Extra Clearance" cage guides are now available to give extra ball clearance for large foreign particles, such as Frac Sand, Gyp particles, scale and for viscous fluids. Readily interchangeable or replaced.

JOHN N. MARTIN

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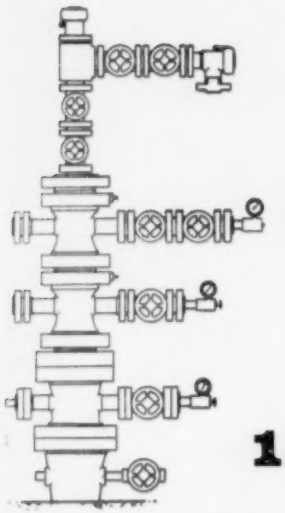

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INSURES SAFETY
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AT WORKING
PRESSURES TO

15,000 psi

WHEN PRESSURES RUN HIGH, RECTOR gives you control that is absolute. Exclusive *seal-with-steel* feature means positive *metal-to-metal* seal that is the trademark of Rector design and safety.
Rector equipment meets all standards of the API and the Association of Well Head Equipment Manufacturers. Tested to 22,500 psi as stipulated in API Test Specifications.
Check these features that make Rector well head equipment the standard of the oil industry.

1. **Permanent "seal-with-steel" between strings.**
2. **Mandrel recessed for RECTOR-PSI full opening back pressure circulating valve.**
3. **All flanges are API flanges.**
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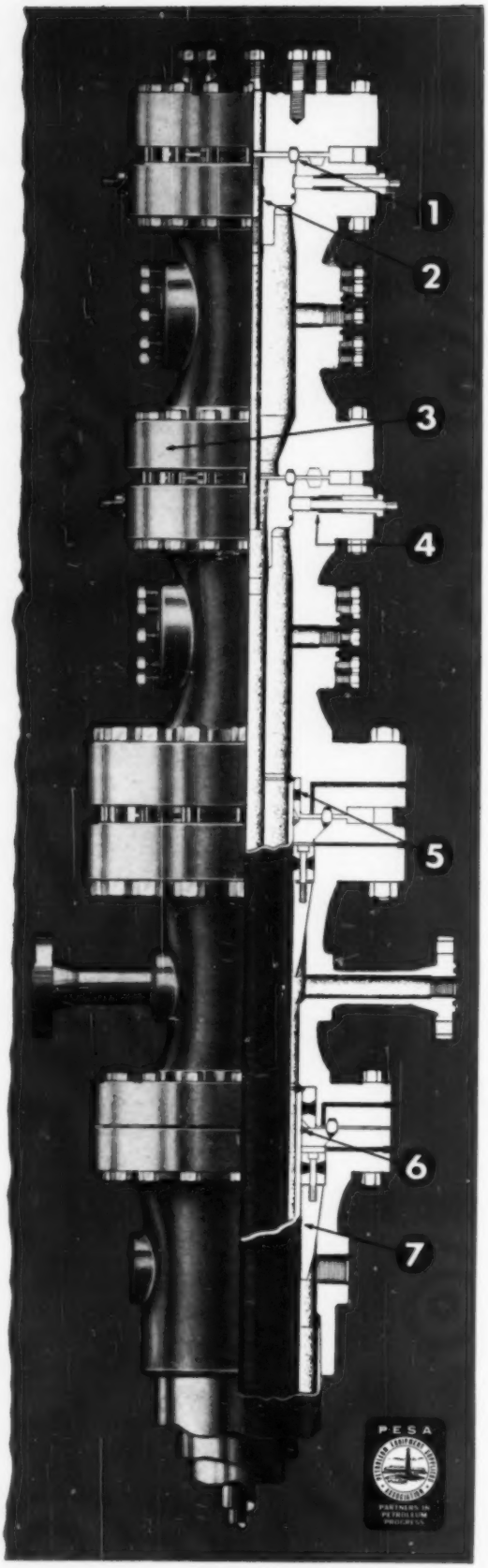
5. **Optional auxiliary secondary pack-off with organic packing "floating ring" seal.**
6. **Permanent "metal-to-metal" seal does not require replacement or maintenance.**
7. **"Balance slip" suspension with self-actuated sealing mechanism.**



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Du Pont announces new "Qualex"...

... a highly refined grade of CMC to help you solve special drilling mud problems

New Du Pont "Qualex" is *over 99.5% pure.*

This highly refined grade of CMC is now available to help you solve those special drilling mud problems that demand the very highest in purity. It will give you maximum effectiveness in controlling mud viscosity and fluid loss in the hole.

And to help you further improve drilling efficiency, "Qualex" is available in two viscosity types:

High Viscosity "Qualex" promotes faster drilling rates by minimizing the quantity of clay solids required to maintain the desired mud viscosity.

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Du Pont's complete line of CMC types and grades is your answer to widely varied mud problems.

FOR MAXIMUM PURITY

Du Pont "Qualex" grade CMC—High Viscosity
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Your mud dealer can give you immediate delivery of either the "Qualex" refined grade or "DM" technical grade of Du Pont CMC. Call him, or get in touch with Du Pont, Explosives Department, 6539 Nemours Building, Wilmington 98, Delaware.

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DU PONT CMC

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Better Things for Better Living
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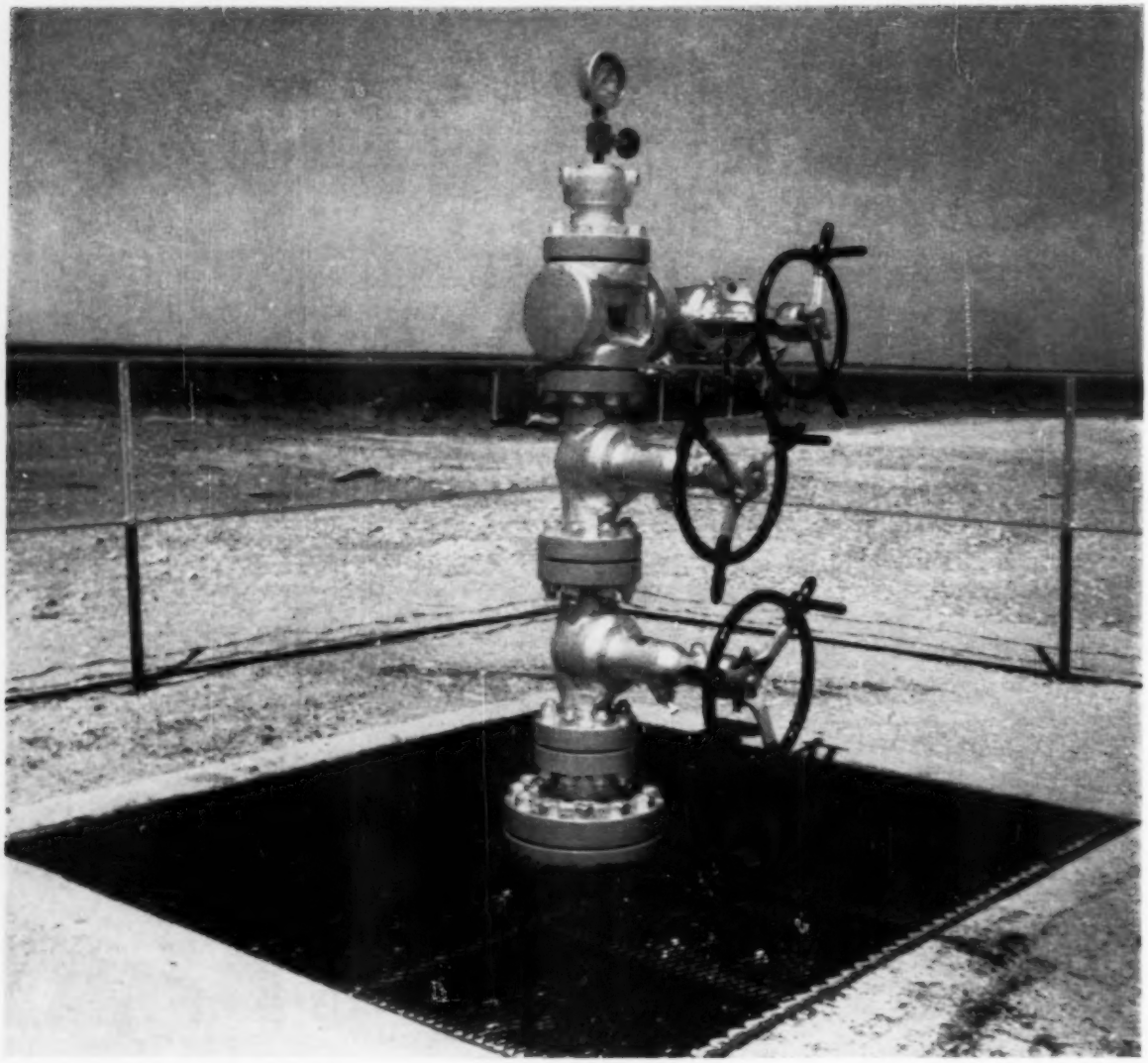

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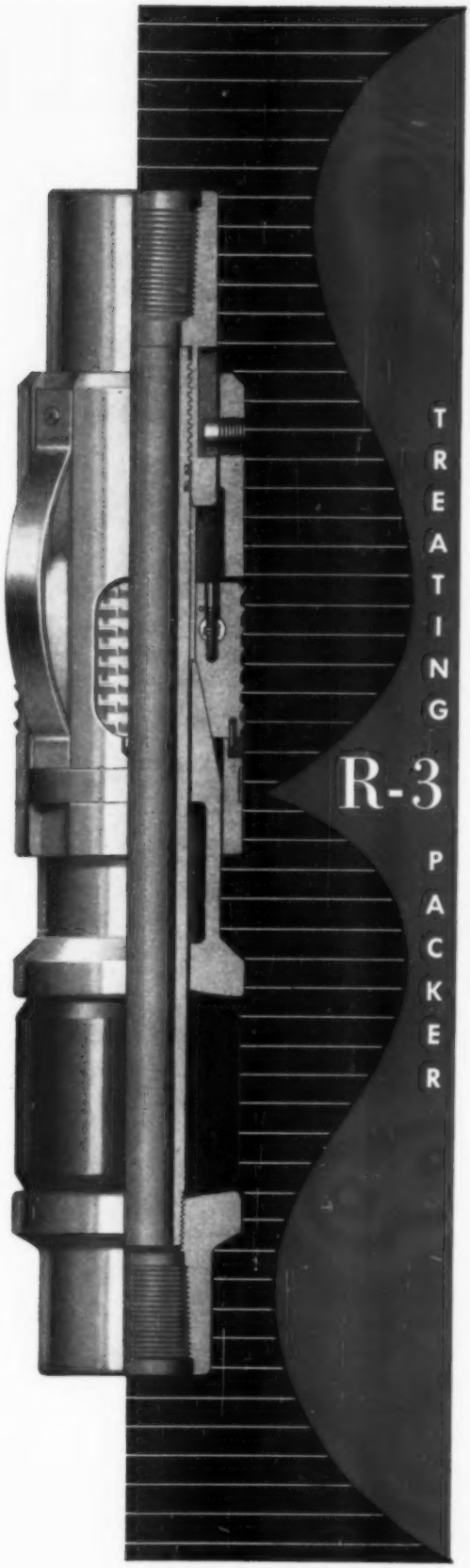

HERE'S THE ANSWER... for shallow well packers!

The new HALLIBURTON R-3 TREATING PACKER for treating, water flooding and producing... can also be used in shallow or low-fluid wells. Short... compact... retrievable ...and dependable, for running on tubing to isolate sections... for *workover and treating* under pressures up to 5000 psi differential. Can be run as tension or compression packer.

The need for tubing hold-down... as in conventional hook wall packers... is eliminated when set in tension since the R-3 *TREATING PACKER* is self-anchoring against pressures from below. When set in compression a hydraulic tubing hold down is used. This arrangement offers the true practical operation for use of this packer at shallow depths.

- Full-opening mandrel permits passage of wire line type tools, instruments or perforating guns.
- Retrievable, may be set and reset on one trip in hole or used from well to well.
- Design makes redressing and replacement of parts a single operation.
- Safety joint allows tubing to be removed. Packer is easily drilled if conditions prevent normal removal.

Halliburton Oil Well Cementing Company now proudly adds the R-3 *TREATING PACKER* to its field-tested and proven line of superior quality packers. From the same engineering skills and years of successful experience, that has made Halliburton *foremost in oil well servicing*, comes this newest tool to fill a specific need.

Call your nearby Halliburton Representative for purchase price and full details on the "money-saving" R-3 TREATING PACKER.

HALLIBURTON

CEMENTING SERVICES

HALLIBURTON OIL WELL CEMENTING COMPANY
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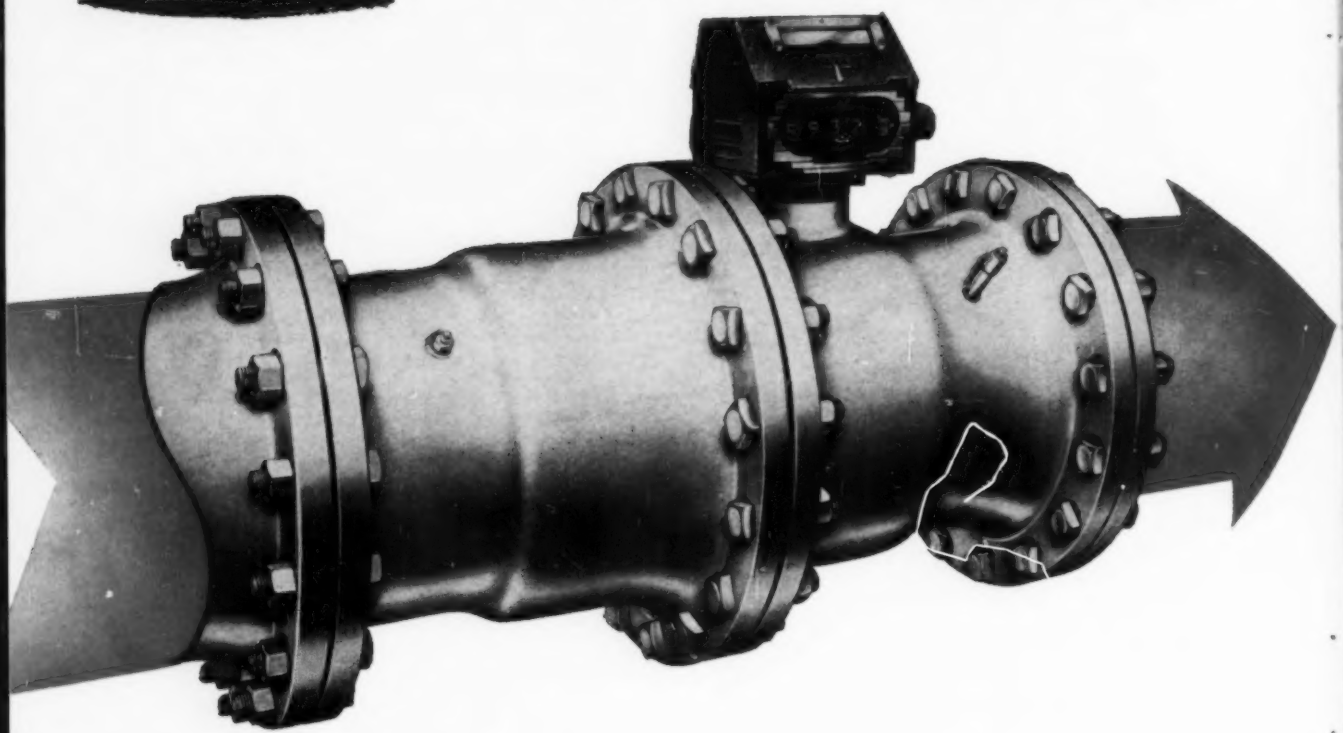
NEW ROCKWELL



FULL STREAM AHEAD...

Up to 15,000 barrels per hour

with negligible head loss

FOR PIPE LINE CONTROL, BARGE LOADING, CUSTODY TRANSFER

Measures accurately everything from heavy crude oil to finished products *without manual adjustment* for changes in viscosity

The Rockwell Turbo-Meter is a turbine meter of revolutionary design which surpasses in accuracy, reliability and flexibility any positive displacement or any high flow capacity meter now in use.

Measurement is accomplished by a balanced, low drag, air foil turbine rotor which revolves quietly on ball bearings. A built-in compensator applies continuous correction for changes in viscosity. Head loss is extremely low. The register, either mechanically or electrically actuated, is driven from a magnetic coupling which eliminates the need for a stuffing box. The entire unit has been constructed to hold its accuracy, repeatability and calibration under continuous service operations.

The Rockwell Turbo-Meter body is the same diameter as 16″ pipe. Its weight is less than ⅛th that of positive displacement meters having the same capacity and its cost is less than half.

Write for bulletin OG-417, Rockwell Manufacturing Company, Pittsburgh 8, Pa.

TURBO-METER

*with Built-in Viscosity Compensator**

THE FIRST MULTI-PURPOSE, LARGE CAPACITY METER CAPABLE OF ACCURATELY MEASURING LIQUIDS OF VARYING VISCOSITIES UNDER CONTINUOUS SERVICE CONDITIONS

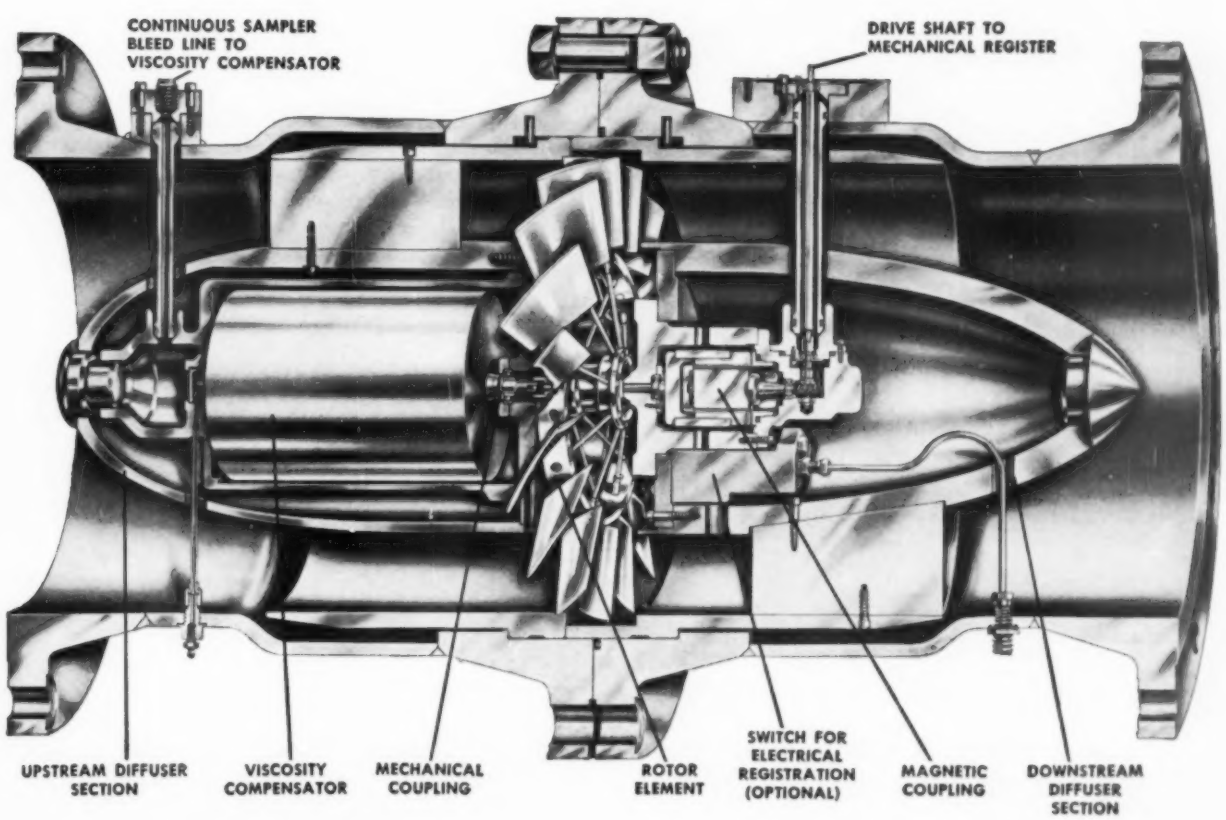
The Rockwell Turbo-Meter differs from conventional turbine type meters by incorporating a system for automatic correction of viscosities. A token amount of filtered line fluid is bled through the compensator which puts a varying resistance on the turbine rotor directly proportional to the product viscosity.

All Rockwell Turbo-Meters are calibrated in the Rockwell Meter and Valve Testing Station on the largest and most precise liquid meter testing equipment ever developed. A certified meter factor curve is provided for each meter.

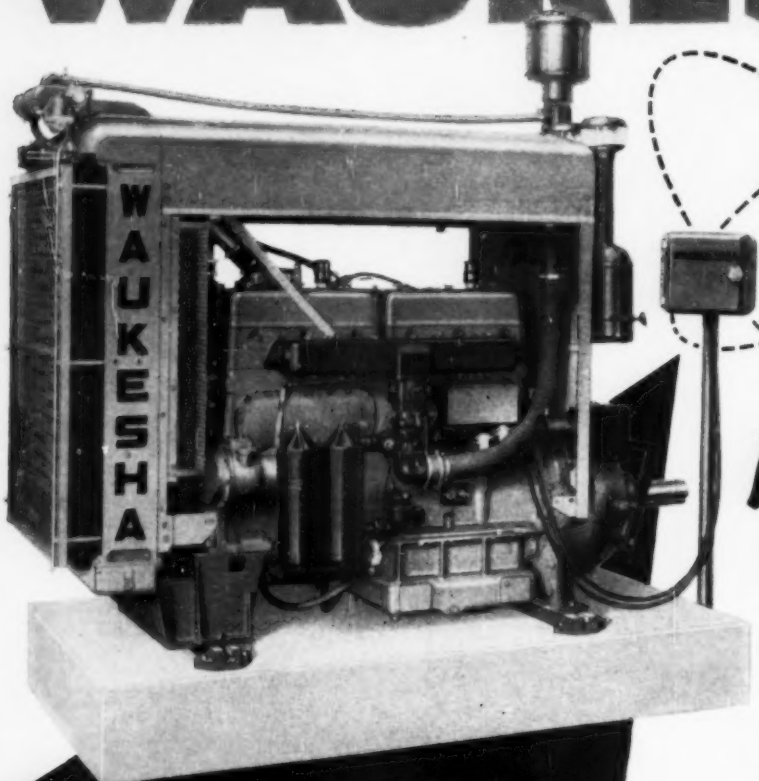
TURBO-METERS
another fine product by
ROCKWELL

*Patent applied for

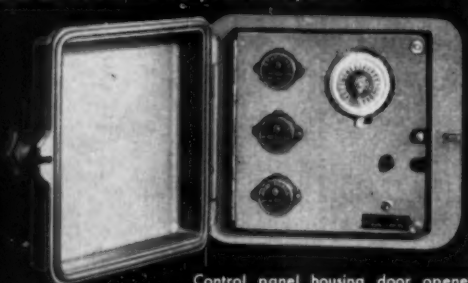
LOOK INTO THE ROCKWELL TURBO-METER



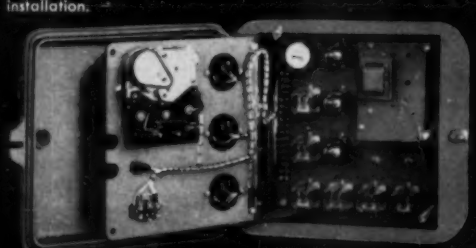
WAUKESHA



Typical Waukesha *Engomatic* Control System Installation on a Waukesha Long-Life Oil Field Unit. Note control panel can be mounted in any convenient position



Control panel housing door opened, showing heavy cast construction, dust and moisture proof seal, starting reset, and time-cycle controls for an *Engomatic* pumping control installation.



Panel open, showing wiring harness, sealed relays and other electrical components, all of highest quality, and designed for long life and easy replacement.

423

Engomatic POWER CONTROL SYSTEM

The Waukesha *Engomatic* Control System meets the demand for internal combustion engine automation. All operation is independent of outside power. It is fully protected with safety shutdown devices and has visual indicators and manual resets, and functions with engines using all standard fuels. Operation can be controlled on a time-cycle basis; by remote control; liquid levels or temperatures; or by any signal peculiar to the equipment involved. Send for Bulletin 1731.

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Automatic Start-Stop by Time-Cycle, or Remote Switch • Fused Control Circuits • Three Position Selector Switch for Automatic or Manual Operation • Intermittent Cranking • Low Oil Pressure and High Temperature Protection • Overcrank Protection • Engine Warm-up Period • Automatic Clutch Engagement—single or repeated for heavy load starting • Automatic Clutch Disengagement when engine stops • Dustproof enclosed plug-in type Relays • Waterproof, Dustproof Control Enclosure.

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Factories: Waukesha, Wisconsin and Clinton, Iowa

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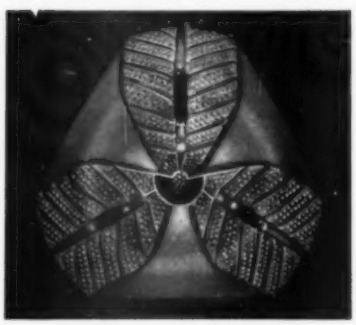
. . . . . another D&S design advance for faster, deeper drilling . . . . . .



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Ultra Fine Diamond Equipment for the Oilfield

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Divided cylinders

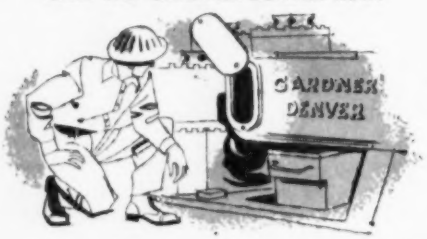
Gardner-Denver mud pumps are designed to keep your mud circulating . . . to handle high drilling pressures continuously without excessive maintenance. They are built with reserve strength to withstand the shock and high plunger loads of deep well drilling.

Each part is designed to ensure maximum service life. All parts are readily accessible for field servicing. Gardner-Denver service specialists are on call throughout the oil fields.

And Gardner-Denver mud pumps are never obsolete. Replacement parts of latest design fit Gardner-Denver pumps already in the field. Invest in the finest of modern mud pumps—Gardner-Denver.

Models from 52 to 1250 hp—a size for every capacity and pressure need.

CALL THE GARDNER-DENVER MAN



Your Gardner-Denver oil field specialist is trained to assist in solving your fluid circulation problems . . . to help keep your mud pump in tiptop shape. At Gardner-Denver *there's no substitute for men*—our 100-year philosophy of growth.

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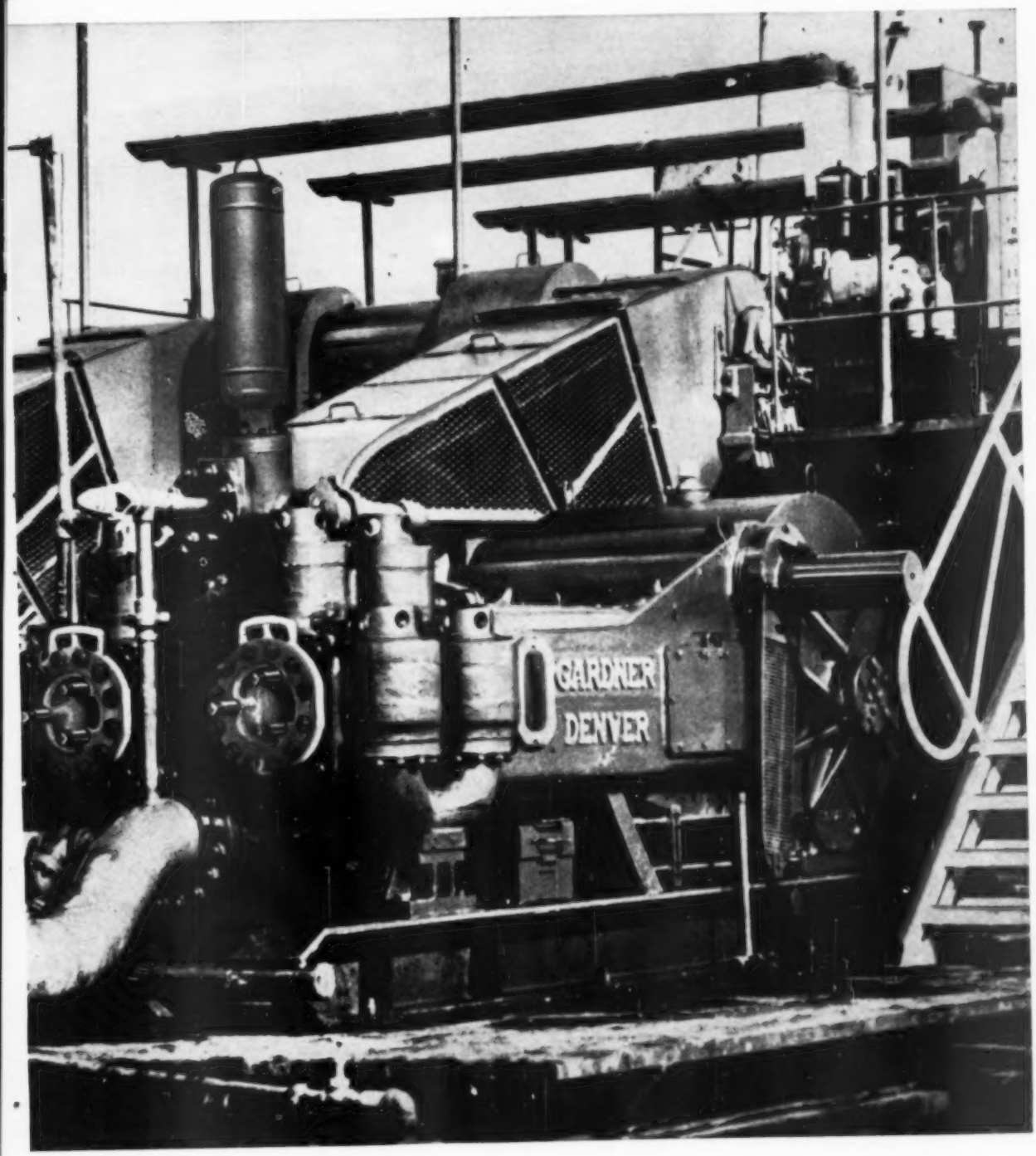
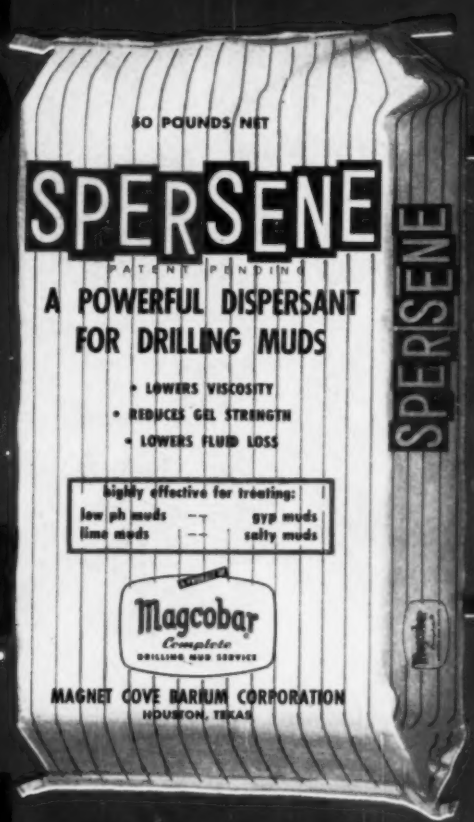
GARDNER-DENVER MUD PUMPS



Now

SPERSENE

Magcobar's *new* all-purpose dispersant cuts costs *in any kind of mud*



another *well done*

Spersene, a very versatile thinner, performs well in any mud. Its powerful thinning action combined with low cost make it a unique chemical for treating any drilling mud. You need no longer stockpile a number of dispersants at your well to meet different mud conditions. Now, you can simplify mud treatments with this new all-purpose dispersant and cut mud chemical costs, too.

Spersene costs less when you buy it; costs much less when you use it. As the tables show, Spersene lowers viscosity more effectively, at less cost, than any of today's leading thinners. This means a lower cost per barrel with Spersene. When projected to well volume, it means surprising savings. Whether you are using high or low pH mud, gyp mud, lime mud, or seawater or brackish mud, laboratory tests prove that Spersene

	Amount (pounds)	MATERIALS	Average Cost (Cents)	VISCOSITY (Yield Point-lb./100 ft.^{2})
gyp muds	1	Spersene	16.5	7
	1	Thinner A	18.5	14
lime muds	3.0	Spersene	49.5	6
	3.0	Thinner A	65.5	16
low pH muds	1	Spersene	16.5	8
	1	Thinner A	18.5	12
	2	Thinner B	20.0	20
	1	Thinner C	18.0	18
	1	Thinner D	17.0	31
sea water muds	4	Spersene	66	1
	4	Thinner A	74	3

is more efficient on basis of costs than any other dispersant. And it is very stable against the upsetting effect of salt.

Spersene is one more specific Magcobar solution to the problem of high drilling costs, one more development from the Magcobar laboratories that will increase your profit through more economical drilling. From spudding in to total depth, you'll find that the right products *used right* by Magcobar engineers can cut your drilling costs, too. Write for the new bulletin on Spersene.

Wherever your drilling operations, you can use Magcobar engineering and products. There are more than 500 stockpoints in the U.S. and Canada. Elsewhere, write Foreign Operations, P. O. Box 6504, Houston, Texas

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Complete
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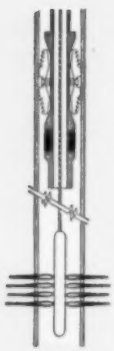
Here's what you can do with the **BAKER FULL-BORE RETRIEVABLE CEMENTER**

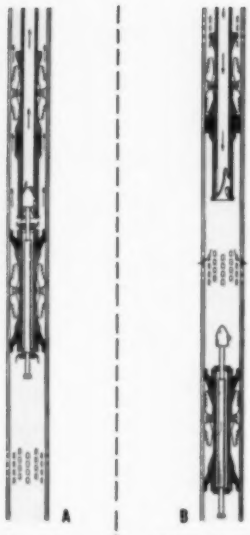


PERFORATE

FRACTURE
ACIDIZE
CEMENT

SWAB
AND
TEST

or use it with a **BAKER RETRIEVABLE BRIDGE PLUG** for as many straddle operations as required... in **ONE ROUND TRIP!**

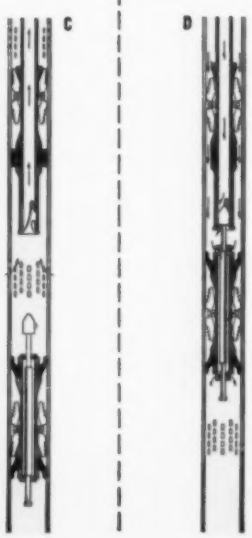


Run tools in together

Release Plug, straddle interval, fracture or acidize

Swab and Test

Pick up plug, move to next interval



here's why it does these jobs better...

HOLDS HIGH PRESSURES FROM ABOVE OR BELOW Contains two sets of opposed "Rocker-Type Slips". Once packing element is packed off, pressure from above or below is automatically transferred through the proper set of slips to the casing.

FULL-BORE (Tubing I.D.) permits passage of instruments, or guns; prevents "screen-out" during fracturing operations.

Baker Full-Bore Retrievable Cementer Product No. 410

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Write for Catalog Supplements 319, 322, 323 for complete information on these products and their applications.

P 594.5

THE ATLANTIC LECTURES OF THE UNIVERSITY OF TEXAS

PART 9

What to do about SALT WATER

The oil industry produces every year enough salt water to provide 100 cu ft of salt for every person in the United States. The handling and disposal of this salt water is one of the biggest non-profit businesses in the world

Henry Lewelling, *Senior Chemical Engineer* and **Monte Kaplan,** *Chemical Engineer*
Atlantic Refining Company, Dallas, Texas

WHETHER WE LIKE IT OR NOT, salt water is almost always produced along with oil or gas. It is a by-product, a waste material that must be disposed. We do not make any money from it — on the contrary, it costs us money to handle. We are required by good citizenship, and often by law, to handle it in such way that it does no damage to plant and animal life. What then should a petroleum engineer expect to face in regard to salt water production? What kind of problems does he encounter? What decisions does he have to make to solve them? What basis of data and experience can he use in arriving at these decisions?

If we try to learn the size of the problem presented by salt water in the United States, we run into trouble. We find that records of salt water production are often poor, and, in many cases, they do not exist. However, we can estimate from our own experience the amount of salt water that was produced in a given year. In the year 1956, for example, about three billion barrels of oil were produced. We estimate that at least two barrels of water were produced for each barrel of oil, making a total of six billion barrels or more.

Now, how much water is six billion barrels? This is a figure that is difficult to visualize. One way of looking at it is that this amount is the equivalent of 800,000 acre ft. This is the size of Lake Buchanan on the Colorado River, which is one of the larger lakes in Texas. Another way to visualize it is that this amount of water would fill a rectangular tank 100 ft deep, 1000 ft wide and 16 miles long. If we evaporated this water, the salts remaining would weigh about 125 million tons. This would make a cube about 1250 ft on a side. If we distributed it evenly, it would give every person in the United States about 100 cu ft of salt to get rid of. From this illustration, you can see that salt water is a problem of considerable magnitude in the oil industry.

Disposal Methods

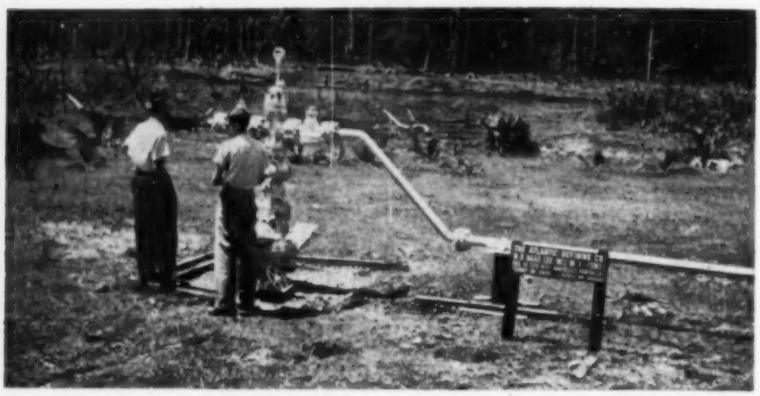
Natural streams. In the early days of the oil industry, salt water was simply separated from the oil and allowed to flow by natural drainage into the streams. This practice had a serious effect on plant and animal life. Plankton in the streams could not tolerate the salt. The fish were deprived of their natural food, so they died out. Animals depending on fish moved on to better hunting grounds. In certain older oil producing areas, extensive plots of ground are still barren, with no living vegetation. This is the result of contamination by salt water.

Evaporation. Much later a few operators started storing their salt water in earthen pits. This method is still practiced in many areas, particularly where evaporation is a fairly rapid process. It is still used to a considerable extent, for example, in West Texas. It is an inexpensive method when it is suitable and permissible. Often it is necessary to build an evaporation pit on a slope, such as the side of a hill. In this case, a common practice is to build a low dike on the upper side of the pit. Thus, rain water will not drain into the pit, overfilling it, and subsequently dumping salt water.

Dumping in salt water bodies. Another disposal method that is used widely, where it is geographically possible, is dumping the water into an adjacent salt water body, such as the Gulf of Mexico. This method has the ad-

Salt-water damage can be more destructive than fire. If salt water is allowed to flow freely over cultivated land, all vegetation is ruined and the land is rendered completely useless for further cultivation. Scenes such as this have led to the controlled disposal of billions of barrels of salt water every year in the United States.

Water treating plant prepares water for disposal either by injecting it into some formation that will accept the brine, or by injecting the treated salt water as the driving fluid in a salt-water flood.



Disposal well controls the injection of treated salt water into an underground formation.

vantage of being quite inexpensive. However, the authorities insist that separation of oil from the water be highly efficient. In some cases, we have been required to keep oil content below 30 ppm. This is so small an amount that it is barely visible as a faint "rainbow" under the best viewing conditions. The presence of a small quantity of oil on these waters has a serious effect on the fish and oyster population. They acquire a very unpleasant taste. This fish and oyster business is a strong industry in the oil producing states bordering the Gulf. Its well-being is zealously guarded, both by the people in the business, and by the game and wild life authorities of the respective states.

Underground injection. A more sophisticated method of disposing of salt water is to put it under the ground, back into the earth from which it came. This is done by injecting it into some permeable, porous formation, which will accept the injected brine. We can find a suitable disposal formation in nearly any geographical area where oil can be produced. This method is encouraged by the various authorities, such as regulating bodies and the wild life conservation people. It is usually favored by the royalty owners. It bears the mark of good citizenship, showing that the operator is acting in good faith to prevent contamination and damage, often at considerable expense. The disadvantages of subsurface disposal are largely in economics. Usually, the method costs much more than some of the methods previously mentioned. This is because of the higher initial cost, plus the many operating problems that are apt to occur.

Salt-water flooding. One important form of subsurface disposal is water-flooding, in which the produced salt water is re-injected into the formation from which it came. The water handling problems are no different from those of other subsurface disposal systems.

Why Disposal?

One question we might well ask is, why bother with disposing of salt water at all? It costs a certain amount of money, which eats into profit on the production of oil. It is a bother and a nuisance to the people concerned. What justification do we have for doing it? This is a good question indeed. There are at least two pertinent answers. In the first place, a strong trend toward good citizenship in industry has been developing for some years. There was a time when the only concern in most industries was for profit. However, in this century, we have seen great improvements in both industrial relations and public relations. Industrial concerns have become more and more conscious of their social and community obligations. Along with other industries, the oil industry has tended toward better citizenship. We have done much toward keeping our properties in better condition and minimizing damage to surrounding properties. We have, for example, installed many salt water disposal plants. These plants involve costs ranging up toward $100,000.

In the second place, there is the legal aspect. Most of the states that have been in the oil producing business for several years have adopted some form of laws regarding the disposal of salt water. This is because companies are like people. Some are negligent in this matter and must be urged. In recent years, Mississippi, Arkansas, Oklahoma, Kansas, and New Mexico have enacted new legislation which was intended to prevent damage by waste material from the production of oil. Also the United States Congress recently has enacted similar legislation. This provides that where contaminated waters flow across a state line, and where the receiving state complains, the Federal Government can intervene. It can hold hearings and, by due process of the law in Federal Court, can cause the damage to be stopped. So far, the enforcement of this legislation, both State and Federal, has been approached with understanding and with patience. These situations are often difficult because of economics. The high water producing leases usually are marginal oil producers, providing little income to be used for water disposal. In most hearings so far, when an operator has been acting in good faith, the authorities have been very realistic and cooperative. However, it should be understood that the legislation, both State and Federal, is so written that the penalties can be severe for failure to comply.

Characteristics of Oilfield Brines

The characteristics of those brines associated with the production of oil are considerably different from the characteristics of fresh waters. We are all familiar with the characteristics of pure water, because they remain constant. We know that pure water contains an equal number of hydrogen and hydroxyl ions. We know that it will not conduct electricity. We know that its

pH is exactly 7. We know that it has certain physical characteristics of freezing point, boiling point, surface tension, index of refraction, etc. All of these characteristics will be different in oilfield brines. They will vary from brine to brine, and will differ considerably from the characteristics of fresh water.

Soluble mineral salts. An oilfield brine contains mineral salts in solution. Of course, the amount determines the salinity of the brine. Sodium chloride is the largest mineral constituent of most oilfield brines. Such a brine normally contains the positive ions: Sodium, potassium, magnesium, and calcium. It also contains one or more of the negative ions: Chloride, sulfate and bicarbonate. Usually, it will contain a number of other ions in lower concentrations. The concentration range of the total dissolved solids may extend from about 1000 milligrams per liter up to 300,000 milligrams per liter, or more. The pH of an oilfield brine may be any value from something lower than 5 to higher than 8. The specific gravity varies with the concentration of dissolved solids.

Sometimes we find some interesting peculiarities of salt concentration in oilfield brines. It is not uncommon, for example, to find an oilfield brine which we cannot synthesize readily in the laboratory. This means that the proper amounts of the minerals (carefully determined by analysis) cannot be dissolved and kept in solution in water by normal laboratory procedure. The fact that the oilfield brine contains these chemicals in solution is evidence of a super-saturation which we do not duplicate in the laboratory. The amount of coexistent barium and sulfate ions, for example, is frequently far in excess of what would be expected from handbook data. Of course, an upset in the equilibrium of saturation will cause the precipitation of some salt which was contained in solution. This is a common phenomenon, and when it occurs, we have the formation of scale.

Suspended solids. In addition to the dissolved minerals contained in a brine, it usually carries certain materials in suspension. These suspended solids may have originated in the formation; they may have been picked up in the well bore, or in the surface equipment. Often the suspended solids contain silica in the form of finely divided sand or silt, which came from the producing formation. Also, they often contain organic material. This may consist of oil or bacteria or other organic complexes. Sometimes the suspended solids contain a small amount of one of the precipitated salts from the dissolved minerals. This may consist of calcium or barium sulfate, or one of the carbonates. In addition, a certain amount of iron is usually found in the form of hydrated iron oxide. Some of the iron may originate in the formation, but a frequent source is from corrosion of metal through which the brine flowed in the producing equipment. This corrosion forms soluble iron salts, such as ferrous chloride or sulfate. Oxidation, as from exposure to air, causes the iron oxide precipitate to form. Brines containing hydrogen sulfide corrode the steel to form insoluble iron sulfide, which will be found in the suspended solids. (Oxidation converts this to iron oxide, so that analysis of an aerated sample for sulfides will be misleading.) These suspended solids are the source of one of our more trying problems in the subsurface disposal of oilfield brine.

The recognizable characteristics of an oilfield brine depend on the dissolved minerals, rather than the suspended solids. These characteristics vary widely from brine to brine. However, it is fortunate that within a given formation the characteristics of a brine will tend to be uniform. The minerals in solution in a salt water appear to be typical of the formation itself. Therefore, the amount and proportion of these minerals to each other will remain fairly constant anywhere in a formation. For example, water from the Arbuckle in Kansas has been sampled from many different points in the state, and in each case, the mineral content of the brine forms a similar pattern of concentrations.

On the basis of this fact, a method was developed several years ago for simplified identification of brine.[1] The comparison of salt water analyses from several samples is a laborious process when using data in tabulated form. It is a process that is likely to lead to errors. The pattern method of identification was developed to overcome this difficulty. This method involves the plotting of the mineral content of the brine in a graphic form which permits the ready and quick comparison of one brine analysis with another. The method is quite useful in many problems. Geologists, for example, often use the pattern in the correlation of formations. Another example is in the evaluation of a suspected casing leak. Often we can determine from pattern study that the casing is leaking, and that the formation brine is being diluted by a water from above. In some cases, we can determine what formation is causing the dilution, and the approximate amount. Thus, by this method, we can decide whether there is a casing leak without having to go into the well with workover equipment.

Disposal Problems

Having looked at the characteristics of brines, what problems can we expect to encounter in disposing of them? Insofar as surface disposal is concerned, such as into a pit, the only problems that will be involved are:

1. The oil must be separated from the water with efficiency.
2. The equipment must be protected against corrosion, within the limits of economics.
3. The equipment must be protected against excessive deposition of scale.

The requirements for subsurface disposal are somewhat more elaborate. In addition to the above, it is also necessary to remove the suspended solids from the water. This is so that the face of the injection formation will not be plugged with these solids. Also, the injection well must be protected so that there is no risk of a leak through the pipe or along a faulty cement job, which could cause contamination of one of the fresh water sands.

A few examples of subsurface disposal systems will show how these requirements are met. The simplest subsurface disposal system consists of a disposal well and a line leading to it from the separator. This is possible only if the well is so receptive that it will take water under vacuum, and if the water has small enough amounts of suspended solids that no damage will be done to the formation. In addition, the water should have no tendency to corrode the metal, and should not tend to form scale. Unfortunately, it is not often possible to find such ideal circumstances.

Aerated systems. Some of the most complex systems are those in which the brine is aerated before disposal. This type of system is used by the East Texas Salt Water Disposal Company. They have no control over the water they receive from their customers. Much of this water has gone through open gunbarrels and therefore is aerated. Also, aeration is needed in order to remove hydrogen sulfide before disposal.

Water is received from the various separators into an open skimming pit. Here excess oil is removed. Also, the water is purposely aerated before passing into an open settling basin. Chemicals are added here for the purpose of flocculating and coagulating the suspended solids, so they will settle more readily. The water then passes through filters into a clear water accumulator tank, before being pumped into the disposal wells. Corrosion is always a problem in an open system like this, due to the dissolved oxygen in the water. Also, it is often necessary to add chemicals for the control of microbial growth or algae.

Closed systems. A system which we

Formation of scale in water-handling equipment is formed by precipitation of certain chemical ions dissolved in the brine. Prevention and control of scale is one of the most troublesome phases of salt-water disposal.

Corrosion of brine-handling equipment can be caused by acid gases, dissolved oxygen, or galvanic destruction.

see more often is one in which air is never allowed to contact the salt water. This may be used if the water contains no hydrogen sulfide, and if air is never allowed to contact the water. Under these circumstances, the iron salts that are present in the water will remain in solution. Thus, the need for treatment is minimized. In a typical system of this sort, the water goes through some device to separate any traces of oil. This may be a skimming tank or a precipitator. In this vessel, the water is kept covered with oil or gas to protect it against exposure to the air. The water then passes through a filter and into a clear water accumulator tank, both of which are also protected from exposure to air by an oil or gas blanket. Water is taken from the accumulator tank to the disposal well.

In each of these systems, or in any modification of one of these systems, we must safeguard against plugging of the formation from suspended solids in the water. We must also protect the equipment from undue corrosion damage in the piping and in the vessels. We must protect against emulsions and against scale formation. The problems, therefore, of handling salt water for underground disposal are resolved to problems of scale and precipitation, of corrosion, of emulsions with oil, and of microbiological life.

Formation of scale. Scale in water-handling equipment is caused by the precipitation of certain chemical ions which were once dissolved in the brine. Scale is most often found in two chemical forms. One form is carbonate scale, and the other is sulfate scale. Carbonate scale usually consists of calcium carbonate. It is formed when equilibrium of carbonate, bicarbonate and carbon dioxide is upset.[2] This upset may be due to some change in temperature or pressure along with the turbulence of production. Carbonate scales may be formed anywhere in the system, from the perforations in the producing well to the disposal well. Carbonate scale can be very troublesome indeed, but it can be removed by simple acidization; therefore, it is less serious than sulfate scale.

Sulfate scale is normally formed out of a super-saturation of barium or calcium sulfate.[3] It may also occur due to mixing unlike waters, such as a high sulfate water with a high calcium water. Like the carbonate scale, it may occur anywhere in the system. Sulfate scale is difficult to remove by chemical means when it has once been formed. Ordinary acid treatment or other chemical treatment has little effect. If it is known that sulfate scale is likely to be troublesome, then it is better to take preventive measures. This may be done in several ways. If the scale is formed due to some upset in equilibrium in the water, it may be possible to avoid that upset. An example of this is the upset which occurs on the fire-tubes of a heater treater. Very often, sulfate scales are laid down at this "hot" spot.

Another means of preventing formation of sulfate scale (or of carbonate scale) is by the use of inhibiting chemicals. Many chemicals are offered to the industry for this purpose, some of which may be of doubtful value. It is extremely difficult to evaluate such inhibitors except by field trial. This, in itself, is an expensive and time-consuming process. The wise engineer will attempt to learn from the experience of other operators about the chances of success in applying a scale inhibitor. The complex polyphosphates and certain complex organic molecules are often used in the prevention of scale.[4]

Another means that may be employed to prevent the formation of scale is the simple dilution of the brine. If the scale is formed from a super-saturation of certain molecules, then sufficient dilution with a water containing a smaller amount of these molecules will prevent this scale formation.

Another method of handling scale is to cause the precipitation to take place under controlled conditions. In the open system, for example, it would be convenient to precipitate sulfate by the addition of excess calcium (lime). This reaction would be completed in the settling basin, where the flocculating and coagulating agents would cause the precipitate to settle.

Corrosion. In addition to the problems caused by scale formation, we also are frequently plagued by problems of corrosion. In fact, corrosion is one of the more common sources of trouble and expense associated with the handling of salt water.[5] Damage or failure of equipment due to corrosion, leads to the cost of repair or replacement. In addition, the plant may be shut down for a period of time, which may cause curtailed production. Corrosion also may lead to contamination and damage from leaks. The effects of corrosion, therefore, must be considered in planning an installation for the disposal of salt water.

Corrosion normally occurs in several different forms in water handling systems. One type is due to the presence of acid gases. The acid gases that are most often found in oilfield brines are carbon dioxide and hydrogen sulfide. Carbon dioxide combines with the water to form carbonic acid, and this is quite corrosive to iron and steel. Carbon dioxide is often a natural constituent of the gas that may be produced with the water from the oil. Hydrogen

sulfide, when present, will cause damage due to the formation of hydrosulfuric acid. This acid is very weak. It gives only a feeble acid reaction, but is quite corrosive in relation to its acidity.

Another common type of corrosion which is often encountered is that caused by dissolved oxygen. It is rare that oxygen is an original constituent of oilfield salt water. Most generally, the presence of oxygen is due to the aeration of the water, either purposely or inadvertently.

Another common form of corrosion is the galvanic destruction of the metal. This occurs when there is some difference in potential between the iron or steel and some other part of the system. Galvanic corrosion may be general throughout the system, or it may be confined to small local cells. It may be internal, or it may be external if the equipment is buried or submerged. It is difficult to predict the problem in this kind of damage. When localized, it may be very troublesome, and it can cause a great deal of expense in the operation of the system.

Prevention of corrosion may be attempted by several means. A fairly satisfactory, but rather expensive, way is to use equipment which is not subject to corrosion. Such equipment includes plastic pipe, asbestos-cement pipe, cement-lined pipe, and plastic-coated pipe and vessels.

Another means of mitigating corrosion is by the use of inhibitors. These inhibitors are chemicals which are supposed to reduce the corrosivity of the water to a very low level. Most inhibitors form a protective film on the walls of the metal. These inhibitors are polarized chemical compounds which tend to plate out on the metal with an oriented molecule, and thus offer a film of protection against corrosive action. A large number of complex organic chemicals have been proposed for this purpose.

Still another method for the prevention of corrosion is the use of sacrificial anodes. These make the vessel cathodic, and thus protect it from metal loss. Where applicable, such anodes are capable of giving good protection. For example, a magnesium anode properly located in a vessel will offer very good protection against corrosion, providing the walls of the vessel remain submerged in the water. The design of cathodic protection systems (which include geometric relationships of the anode to the vessel and the distribution of current densities) is a complex problem in itself.

Corrosion in a given system may be caused by any, or all, or any combination of these forms of destructiveness. An evaluation of the corrosion must include the potential cost of the corrosion, along with the technical and economic aspects of prevention.

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Oil-water emulsions. Oil-water emulsions and the carryover of oil by mechanical entrainment provide a source of additional difficulty in the operation of water disposal plants. Quite often some amount of oil finds its way into the disposal system. If this oil is permitted to go on into the well, it will accumulate in the pores of the formation near the well bore. This will reduce water injectivity because of relative permeability effects. In any formation, a small saturation of oil will reduce the water permeability greatly. Efforts must therefore be made to reduce the amount of oil entering the injection well.

Separation is done by means of emulsion-breaking chemicals, together with special pieces of equipment. These may be classed as oil skimmers and precipitators. An oil skimmer may be any type of vessel which permits oil to rise and be removed while the water is flowing off below. On the other hand, water passing through a precipitator travels a relatively long flow path due to built-in baffles. These provide extra opportunity for the oil to separate. Also, it passes through a section that is packed with hay or excelsior. This tends to agglutinate fine particles of oil into drops, which then separate more readily from the water. Failure or overloading of this equipment permits oil to proceed through the system. When such a mishap occurs, oil finds its way into a sand filter. The sand filter is very good at removing oil in small quantities from water. However, the presence of oil in the sand filter interferes with its efficiency in removing the suspended solids. It is necessary that great care should be taken to insure good performance of oil separation facilities, both in the lease equipment, and in the water disposal equipment. Operating procedures that will yield the smallest possible amount of oil into the injection well itself should be established and followed.

Bacteria. Living organisms in the oilfield brine occasionally give us trouble in disposal. When this occurs, it is usually caused by algae, in an open system, or by sulfate-reducing bacteria, desulfovibrio desulfuricans[6] in the closed type. The sulfate-reducing bacteria are anaerobic, which means that they do not require air or free oxygen to maintain life. These bacteria get their oxygen by attacking the sulfate from the salt water and reducing it to hydrogen sulfide. This yields oxygen, which they use in their metabolism. The energy which they require may be obtained from the hydrocarbon itself. Thus, a strong growth of sulfate reducers will liberate quantities of hydrogen sulfide into the oil and water, whether the growth is in the formation or in the surface equipment.

This hydrogen sulfide causes the water to be corrosive. Iron sulfide is formed from this corrosion of iron. If the iron sulfide is not removed, it is capable of plugging up an injection well in a short time. Thus, if a strong and thriving colony of sulfate-reducing bacteria exists either in a producing well or in the surface equipment, it can lead to considerable trouble in the handling of the salt water.

A great deal of work has been done in recent years in trying to learn to

combat these bacteria. It is a complicated problem because they occur in many strains, some of which develop resistance to certain types of bacteriostatic or bactericidal treatment. Some, for example, are resistant to high temperatures. Some are resistant to certain types of bactericides; some require certain types of environment in order to thrive.

When we have found sulfate reducers in the system, we must try to evaluate the potential problem they present. We should try to learn how active and troublesome they are. Also, we should try to find out whether they are present only in the well and/or surface equipment, or if they are being produced from the formation. The economic implications also need consideration. A positive test for sulfate reducers does not, by itself, justify an elaborate bactericidal treatment program. For example, if they are being produced from the formation, treatment will not eliminate the source. It can only be expected to minimize the problem. Also, for example, a relatively inactive strain may exist in a water handling system without doing sufficient damage to justify treatment. Each system should be studied, and evaluated on its own merits insofar as sulfate reducers are concerned.[7]

Economics

A final consideration, but far from the least important, in the disposal of salt water is the economics. Always we must remember that handling of salt water and disposing of it is a non-profit operation. It is something we must do in order to continue production, and the lower the cost overall, the more attractive will be the design. Of course, we could design and build a completely trouble-free system that could operate without attention and without difficulty for any amount of time that might be specified. However, the cost of such a plant would most likely be prohibitive. Instead, we must be critical about any suggested piece of equipment. We must decide if it is necessary to the handling of the particular water. Plant design should be as inexpensive as is consistent with the expected life of the field.

However, in looking at the cost of a plant, we must also consider the probable cost of operation of the plant. It is easy to underdesign a plant to such an extent that the cost of running water through it will be too high. Operating cost can then offset the advantages gained in saving money on the plant itself. Operating costs are difficult to define because various companies use different accounting methods. Comparison of operating costs may not be entirely on a uniform basis. However, in our own company, we have found that it costs us approximately ½ cent per bbl to dispose of salt water. This does not include amortization of the plant, but it does include the cost of engineering and administration, as well as the direct operating cost. We feel that this ½ cent per bbl could be reduced somewhat. If we could keep all of our disposal operations at their best efficiency, we probably could cut the cost of disposal to some amount lower than 5 mils.

One of the difficulties in planning a water disposal plant is that often we start it late in the productive life of a field, when there is little remaining oil production to pay for disposing the water. This imposes severe restriction, but it is one of the factors associated with oil production. Normally, companies, since they are not interested in non-essential spending, do not dispose of the water until it becomes necessary, and by then the oil production remaining from the field may be quite low.

Future Developments

Work is being done in the industry and in related industries that may simplify the problem of water disposal, particularly subsurface water disposal, in the future. Chemical treatment is receiving quite a bit of attention. The older municipal water supply methods, used in many open systems in the past, are no longer accepted as routine. Certain steps formerly believed essential are being simplified or bypassed. In many cases, this results in improvement in water quality.

Better chemicals are being developed. The polyphosphates have been used with spotty effectiveness for years to control scale deposition. Now the chemical manufacturers are attempting to design sequestrants whose physical and chemical properties are better suited to the oil industry's needs. Solubility characteristics and reversion rates are being tailor-made in an effort to make these very complex materials more useful.

New corrosion inhibitors constantly appear on the market. We have not yet found the one we want — a cheap one which will give 100 percent protection in any fully-aerated heavy brine at 5 ppm or less. However, the manufacturers are making continuous improvement.

Bacterial control is receiving a lot of attention, too. Work is underway to define the significance of bacteria from the standpoint of the economics of problems they cause or aggravate. Better and more specific bactericides are being developed, although a low-cost, universally usable one is not available yet.

For several years, a number of organizations have been doing research work on the de-ionization of saline waters by various means. It would be fine if such de-ionization could be done in an economical fashion, because this would provide a usable water from a waste material. At present, the processes all look uneconomical, but work is continuing. Also, a few pioneers have started extracting chemicals from oilfield brines. For example, there is a Smackover water in Southern Arkansas which has a rather interesting amount of bromide ion present. One chemical company has set up a plant to extract the bromine from the brine and then inject the brine back into the ground. Traces of many other valuable minerals are found in some brines, and it is possible that as time goes on these may be exploited.

Automation is beginning to show up in salt water treating plants. While it costs more to install a fully automatic plant than one operated manually, the difference is reasonable. At the same time, savings can be made in operating costs because less man-power is required. Also, the automatic plant will probably supply high quality injection water more consistently than a plant that must be operated by a pumper.

One very interesting development has appeared recently. This is a change of attitude in the industry. Operators now are often preparing for the disposal of salt water as a part of the development of a property. They recognize water production as a necessary part of their operations, and take it into account in early planning for developmental costs. This may or may not be economically attractive in present worth money, but it certainly simplifies the problem of handling the salt water when it becomes necessary.

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Up to 12,000 bbl of oil per day has been produced by . . .

GAS-LIFTING through the annulus of a well

Much information concerning gas-lift flow through tubing has been published. This paper correlates the information to flow through the tubing-casing annulus and presents a procedure for the design of such a system

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MUCH HAS BEEN published on the vertical simultaneous flow of two or more fluids through a pipe. In numerous applications, such as chemical reactions and heat exchange, multiphase flow is of everyday occurrence. The general problem of predicting pressure drop for the simultaneous flow of gas and liquid is complicated. Studies have been primarily confined to short lengths of pipe of small diameter and to the case wherein there was assumed to be no mass transfer between the phases flowing. For most pilot plant and plant design requirements, such assumptions are usually valid. In addition, many studies, particularly those made in the universities, had as their objective a better understanding of the mechanism of the multiphase flow behavior and they did not, as a result, lend themselves to generalized, practical, reliable design procedures.

To the authors' knowledge, nowhere in the chemical engineering literature can there be found a generalized reliable procedure for predicting the pressure traverse for the case of multiphase vertical flow of fluids where simultaneous mass transfer is taking place between the fluids, and for the case of vertical flow lines up to three miles in length and anywhere from several inches to 10 to 12 in. in diameter.

The problem consists of being able to predict the variation of pressure with elevation along the length of the vertical flow string for known conditions of flow. The ability to do this in the case of flowing oil wells would provide a means of evaluating the effect of tubing size, flow rate, bottom-hole pressure, and a host of other variables on one another. In the case of gas-lift installations of oil wells, it would be particularly useful in designing the installation, to provide such information as the optimum depth to which to inject the gas, pressure at which to inject the gas, the rate at which to inject the gas, the horsepower requirements to lift the oil, and the effect of production rate and tubing size on these quantities. In other words, a means of systematically studying the effects of the different variables upon one another.

A generalized correlation based on field data from a large number of flowing and gas-lift wells was published in 1952.[1] The correlation approached the requirements of a general solution applicable to flowing oil wells and gas-lift wells and has given excellent results to date.[1,13] However, the correlation was based on the data for flowing oil wells and gas-lift wells where the flow was through 2, 2½, and 3-in. nominal size tubing, with total gas-liquid ratios ranging from 30 to 5000 cu ft per bbl of liquid.

Recently, a paper was presented by P. B. Baxendell in which data for the flow of oil and gas through the annulus between the tubing and casing were analyzed.[2] Oil flow rates ranged up to 12,000 bbl per day and gas-oil ratios varied from 500 to 2000 cu ft per bbl. In treating his data, Baxendell used the same correlating techniques as described in the earlier paper.[1] However, in so doing, he did not make use of the "equivalent diameter" $(D_i - D_o)$ expression for flow through annuli in the correlating equations.

It is the purpose of this paper to analyze Baxendell's data, using the "equivalent diameter" expression $(D_i - D_o)$ to describe a calculation procedure which will premit the logical design of gas-lift installation where the flow is through the annulus between the tubing and casing of the well, and to discuss the characteristic behavior of gas lift installations.

Theoretical Considerations

The basis of any fluid flow calculation consists of an energy balance on

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Fred H. Poettmann

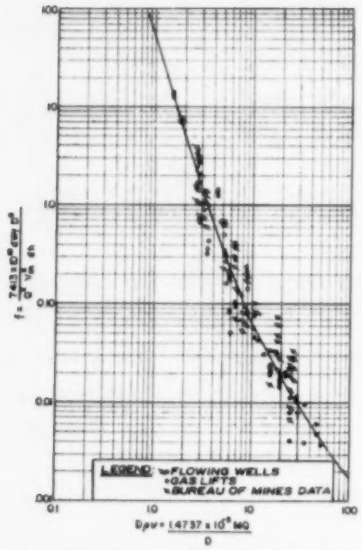

FIG. 1. **Correlation of field data** on flowing and gas-lift wells.

the fluid flowing between any two points in the system under consideration. The energy entering the system by virtue of the flowing fluid must equal the energy leaving the system, plus the energy interchanged between the fluid in flow and its surroundings. It is the energy losses resulting from liquid holdup or slippage effects, frictional effects due to the surface of the tubing, and other effects that were correlated as a function of the flow variables.

Energy balance. Starting with the general energy balance equation,

$$VdP + dh + d\left[\frac{v^2}{2g_c}\right] + dW_f + dW_s = 0 \quad . \quad . \quad . \quad (1)$$

and assuming homogeneous steady flow of the mixture of gas and liquid between any two points in a tubing, no external work, W_s, and neglecting the value of the kinetic energy function, since its value is very small compared to the other energy functions, the equation reduces to:

(The nomenclature employed in the equations is the same as that used in the references and is summarized at the end of this paper.)

$$VdP + dh + dW_f = 0 \quad . \quad . \quad (2)$$

It was assumed that "W_f" for multiphase flow through pipe could be correlated by the well-known Fanning equation:

$$f = \frac{2g_c dW_f D}{4v^2 dh} \quad . \quad . \quad (3)$$

By substituting and rearranging:

$$dh = \frac{VdP}{1 + \frac{4v^2 f}{2g_c D}} \quad . \quad . \quad (4)$$

or, in terms of oil field units:

$$dh = \frac{V_m dP}{M\left[1 + \frac{fQ^2 V_m^2}{7.413 \times 10^{10} D^5}\right]} \quad . \quad . \quad (5)$$

Having available the pressure traverses of a large number of flowing oil and gas-lift wells, along with the PVT data on the flowing fluids, values of "f" were correlated from an integrated form of the above equation, and were correlated as functions of the numerator of the Reynolds number:

$$Dv\rho = 1.4737 \times 10^{-5}\frac{QM}{D} \quad . \quad . \quad (6)$$

The fact that it was possible to neglect viscosity in the correlation of vertical multiphase flow is fortunate and perhaps to be expected. The degree of turbulence is of such a magnitude, in general, for a flowing oil well, that of the total energy loss, "W_f," that portion resulting from viscous sheer is negligible. This is not suprising since it is also true for single phase turbulent flow, where the energy loss is independent of the physical properties of the flowing fluid. A number of others working on the same problem of multiphase flow have made this observation.[3,4]

The correlation is shown in Fig. 1.[1] The approach used in obtaining this correlation differs from that previously used by other investigators in that the use of field data eliminates the problem of extrapolating laboratory data to field conditions. No attempt was made to evaluate the various components making up the total energy loss. The flowing fluid was treated as a single homogeneous mass and the energy loss was correlated on this basis. A total flowing density or specific volume was used rather than an "in situ" density or specific volume. That is, the energy of the fluid entering and leaving the tubing is a function of the pressure-volume properties of the total fluid entering and leaving the tubing, and not of the pressure-volume properties of the fluid in place, which would be different because of slippage or liquid holdup effects. Last, in calculating flowing density or flowing specific volume, mass transfer between phases as the fluid flows up the tubing is taken into consideration, as well as the entire mass of the gas and liquid phases.

Air-lift data. A bulletin published in 1914 by the University of Wisconsin presented results of a large number of laboratory tests on air-lifting water through short lengths of 1¼-in. tubing.[6] These data were carefully recorded and it was possible to correlate a random sampling of this data using the same procedure as described above, Table 1, Fig. 2. For low values of "$Dv\rho$," the "f" factor curve lies to the left of the "f" factor curve for flowing oil and gas-lift wells. At high values, it crosses over the curve for the flow and gas-lift wells.

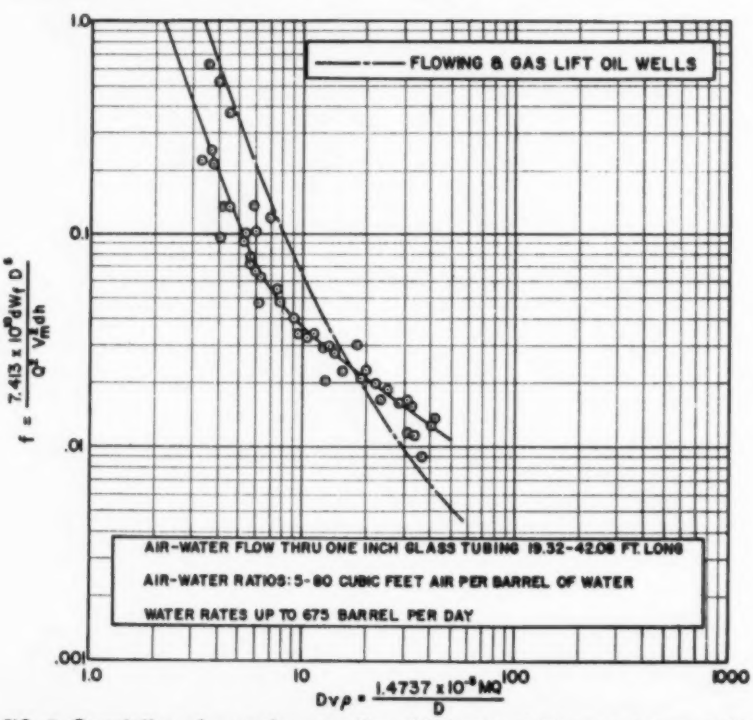
FLOWING & GAS LIFT OIL WELLS
AIR-WATER FLOW THRU ONE INCH GLASS TUBING 19.32-42.08 FT. LONG
AIR-WATER RATIOS: 5-80 CUBIC FEET AIR PER BARREL OF WATER
WATER RATES UP TO 675 BARREL PER DAY

FIG. 2. **Correlation of a random sampling** of University of Wisconsin data on air-lift.

Recently, a paper by Baxendell[2] presented data on the flow of oil and gas through the annulus between tubing and casing of a well. However, in analyzing his data, Baxendell did not use the equivalent diameter $(D_i - D_o)$ for flow through the annulus in either Equation 5 or 6.

In order to employ the correlation for flow through the annulus, the diameter, "D," of the tubing must be replaced by an "equivalent" expression involving the inside diameter of the casing, "D_i," and the outside diameter of the tubing, "D_o." The fundamental definition of equivalent diameter[5] for flow through the annulus is $(D_i - D_o)$. When this is substituted in the basic expression for "D" in Equation 3 or 4, along with the area to flow, $\pi(D_i^2 - D_o^2)/4$, required to convert to the volumetric flow rate, "QV_m," from the fluid velocity, "v," the factor, "D^5," of Equation 5 then becomes:

$$(D_i - D_o)^3(D_i + D_o)^2 \quad . \quad . \quad (7)$$

Similarly, when substituting $(D_i - D_o)$ for "D" in "$Dv\rho$, along with the correct flow area, the "D" in

$$1.4737 \times 10^{-5}\frac{MQ}{D} \quad . \quad . \quad (6)$$

becomes $(D_i + D_o)$. Thus, by using these equivalent expressions for the diameter terms, it should be possible to correlate data on flow through annuli.

Table 2 and Fig. 3 summarize the data from Baxendell's paper.[2] For low values of $(D_i - D_o)(\rho v)$, the data coincide with the data for flow through tubing; whereas at high values, the data on flow through the annuli appears to be leveling off to a constant value. For very high rates of flow where the turbulence is very high, one might expect the value of "f" to level out and become constant. This also appears to be the trend of the University of Wisconsin data. The above-described correlation certainly is subject to additional improvements, so that all the data, such as on the air-water system, correlates with the data on flowing oil wells. It is our belief that the "f" factor has been properly defined and that the improvement will come by properly defining the abscissa of the "f" factor plot.

In the case of horizontal multiphase flow, an improved parameter has already been developed.[7] Nevertheless, the above correlation for vertical flow has proved accurate and very useful in problems involving well bore hydraulics in the oil and gas industry. In order to simplify the design calculations, charts of pressure gradient versus mass flow rate for lines of constant flowing density can be prepared by combining the "f" factor chart with Equation 5. By dividing the equation into "dP,"

TABLE 1. Random Sampling of University of Wisconsin Data on Air-Lift.[6]

Run No.	$1.473 \times 10^{-5}\frac{MQ}{D}$	f	Run No.	$1.473 \times 10^{-5}\frac{MQ}{D}$	f
317	4.48	0.1335	141	25.48	0.0187
338	24.60	0.01813	168	29.08	0.0160
452	9.29	0.03963	190	30.73	0.0161
450	32.09	0.0117	224	33.66	0.0158
447	33.35	0.0114	15	11.37	0.0338
274	42.57	0.0132	42	12.91	0.0282
87	19.11	0.0209	54	13.37	0.0294
8	3.78	0.244	53	14.28	0.0270
315	5.41	0.1026	33	7.87	0.0468
275	41.98	0.0129	32	6.04	0.1030
49	15.53	0.0226	58	6.22	0.0460
31	7.722	0.0541	61	6.18	0.0612
493	12.89	0.0202	64	6.05	0.0652
471	18.14	0.0304	314	5.67	0.0712
490	37.35	0.0088	359	4.08	0.530
318	3.36	0.2240	343	3.64	0.632
1	7.08	0.1176	26	5.93	0.138
17	9.65	0.0339	62	5.64	0.074
20	10.87	0.0327	381	4.33	0.133
100	20.15	0.0227	401	3.72	0.211
118	22.68	0.0197	350	4.51	0.371
131	23.92	0.0163	319	4.01	0.095

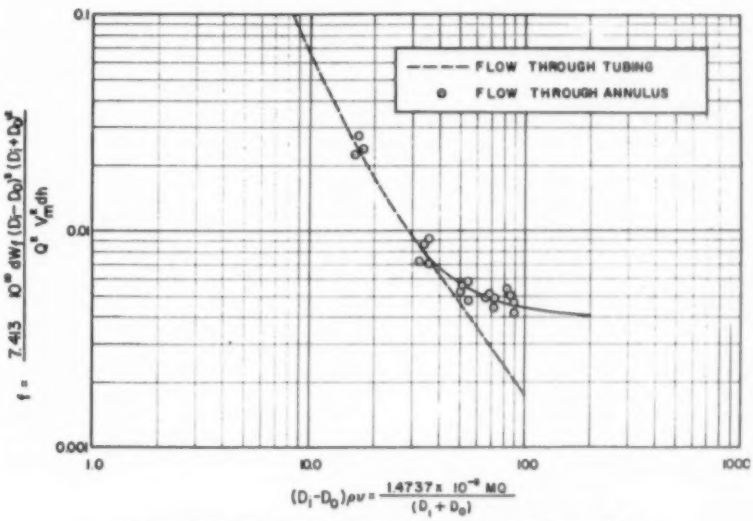

FIG. 3. **Correlation of data** flow through tubing-casing annulus.

TABLE 2. Summary of Data.

$f/(D_i - D_o)^3$ $(D_i + D_o)^2$	$QM \times 10^{-5}$	f	$1.437 \times 10^{-5}\, QM/(D_i + D_o)$
2.07	8.8	.0274	17.0
1.82	9.2	.0241	17.8
1.73	8.5	.0029	16.4
0.54	17.0	.00715	32.9
0.525	18.3	.00695	35.4
0.655	17.8	.00867	34.4
0.682	18.3	.00903	35.4
0.405	25.7	.00536	49.7
0.43	26.5	.00569	51.2
0.44	27.8	.00582	53.8
0.357	27.8	.00473	53.8
0.372	34.0	.00492	65.8
0.385	35.2	.00510	68.1
0.370	37.0	.00490	71.6
0.335	36.9	.00444	71.4
0.410	42.4	.00543	82.0
0.378	44.0	.00500	85.1
0.355	46.0	.00470	89.0
0.314	45.9	.00416	88.8

$D_i = 7$ in. nominal 26 lb per foot $= 6.276$ in. ID $= 0.523$ ft ID.
$D_o = 2\frac{1}{2}$ in. nominal $= 2.875$ in OD $= 0.239$ ft OD.
$(D_i - D_o)^3(D_i + D_o)^2 = 0.01324$
$(D_i + D_o) = 0.762$

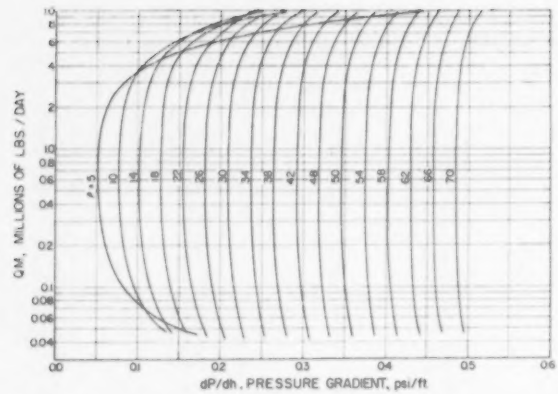

FIG. 4. **Calculation of pressure traverses** for flow in annulus. **Tubing size: 2.0 in.** nominal (4.7 lb per ft, 2.041 in. ID, 2.375 in. OD) **Casing size: 7.0 in.** nominal (26 lb per ft, 6.276 in. ID)

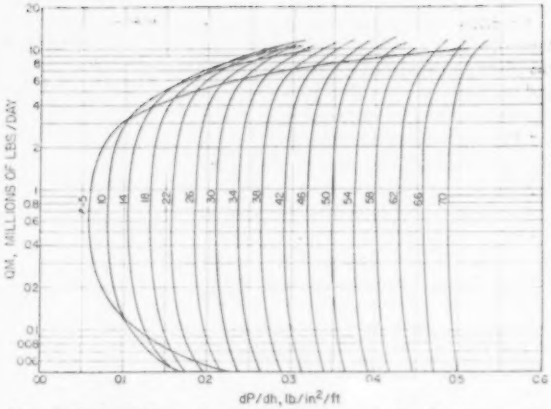

FIG. 5. **Calculation of pressure traverses** for flow in annulus. **Tubing size: 2½ in.** nominal (6.5 lb per ft, 2.441 in. ID, 2.875 in. OD) **Casing size: 7.0 in.** nominal (26 lb per ft, 6.276 in. ID)

the following expression results:

$$\frac{dP}{dh} = \rho + K\rho \quad . \quad . \quad (8)$$

where "ρ" is the density at pressure "P," and "K" can be expressed as:

$$K = \frac{fQ^2M^2}{7.413 \times 10^{10}\rho^2D^5} \quad . \quad (9)$$

Effects of flow rate. For constant tubing or annulus size, "K" is a function of "QM" and "ρ" only, since "f" is a function of "QM" only. Fig. 4, 5, and 6 were prepared for annular flow for given casing and tubing sizes, using the data of Baxendell as correlated in Fig. 3. By determining the density at a given pressure dP/dh can be evaluated at that pressure. Then, by plotting the reciprocal of the gradient versus pressure and integrating, the pressure traverse can be calculated.

It has been reported that in the case of flowing wells having relatively high gas-oil ratios, the wells will die if they are flowed at too low a rate. Also, if flowing at high rates, attempts to increase the rate by lowering the surface pressure results in no increase.

The curvature of the lines on Fig. 4, 5, and 6 is significant in providing an explanation. At both high and low rates of flow, a high gradient is necessary for flow. At some intermediate rate of flow, the gradient is at a minimum value. If the required gradient becomes too large, the well will not produce at the desired rate or may die. At high rates of flow, there is no liquid hangup in the flow string. Energy losses are primarily due to frictional effects, and as velocity decreases, the losses decrease, and the gradient decreases. On the other hand, at low rates of flow, considerable liquid hangup in the flow string results. Here the energy loss is primarily due to the liquid hangup; and as velocity decreases, liquid hangup increases, which in turn increases the energy loss, and in turn the pressure gradient required. The most efficient flow occurs at the minimum value of the pressure gradient. For low gas-liquid ratios, the curvature in the lines decreases.

Gas-Lifting Through Annulus

Gas-lifting is a method of artificial lift which uses the compressional energy of a gas to lift the reservoir fluid. The prime requisite is an adequate source of gas at a desired pressure and volume. Sand, paraffin, and crooked holes offer no handicap. First costs of gas-lift installations are usually lower than other systems of artificial lift.

Wells with high water-oil ratios and high productivity indices, that is, producing large volumes of fluid with high sustaining reservoir pressures, can be efficiently gas-lifted through the well annulus. Quite often it is necessary to produce very large volumes of water to obtain economic rates of oil production. It is often quite common to gas-lift economically as much as 5000 to 10,000 bbl of total fluid per day, with the oil present being 1 percent or less of the total fluid produced, the rest being water. In applying the correlation to gas-lift design calculations, the following procedure is recommended:

a. Establish the flow characteristics of the well, that is, productivity index, water-oil ratio, gas-oil ratio, fluid properties, tubing size, etc.

b. Calculate the pressure traverses

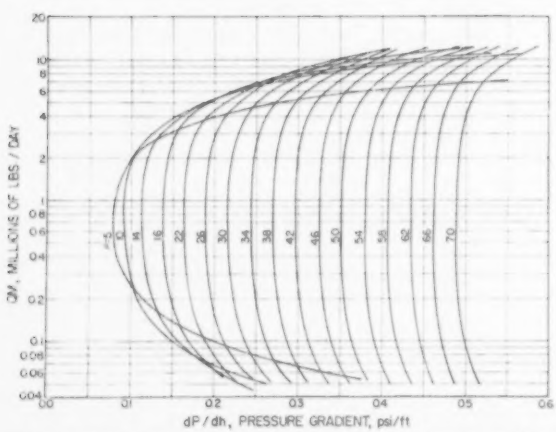

FIG. 6. **Calculation of pressure traverses** for flow in annulus. **Tubing size: 3.0 in.** nominal (9.3 lb per ft, 2.992 in. ID, 3.500 in. OD) **Casing size: 7.0 in.** nominal (26 lb per ft, 6.276 in. ID)

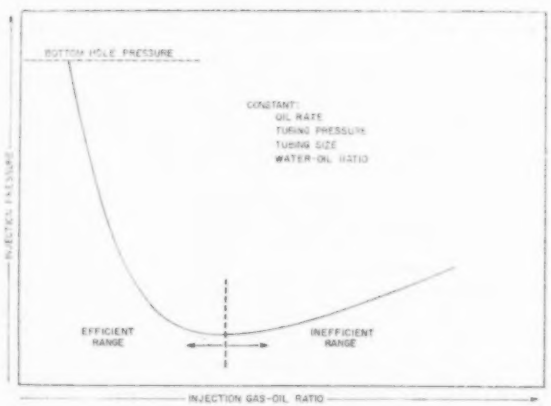

FIG. 7. **Effect of injection pressure** on injection gas-oil ratio.

below the injection point for the range of flow rates.

c. Calculate the pressure traverses above the point of injection for different injection gas-oil ratios, holding the tubing or casing pressure constant.

From the above three steps, the horsepower requirements, injection pressure, depth of injection, and injection gas-oil ratios for a given rate of production, tubing size, and tubing or casing pressure can be calculated.

Optimum conditions. For a given set of well conditions, there is an optimum depth and injection pressure that result in minimum horsepower requirements. In some cases, the optimum injection depth will be at the total depth of the well. There are two ranges of operation in gas-lifting a reservoir fluid. One is an inefficient range characterized by high gas-oil ratios and high horsepower requirements, and the other is an efficient range characterized by low gas-oil ratios and low horsepower requirements.

A plot of gas-oil ratio vs injection pressure is shown on Fig. 7. In the inefficient range of operation, gas is literally "blown" through the flow string. The efficient range is to the left of the minimum injection pressure, and the inefficient range to the right. Inefficient and efficient ranges of operation have been observed in the laboratory on experimental gas-lift involving short lengths of tubing.[6,8,9] One investigator using a large amount of field data from a California field empirically developed curves similar to that shown on Fig. 7, but had no way of predicting these curves for other fields where the physical properties of the fluids and the production data were different.[10]

In a plot of horsepower requirement versus injection pressure, Fig. 8, the horsepower passes through a minimum value which represents the maximum efficiency of the operation. Another interesting result of these gas-lift calculations has been to show that the lower the surface pressure of the flow string that can be maintained consistent with efficient surface operations, the less will be the horsepower required to lift the reservoir fluid.

Other calculations can also be made showing the effect of production rate and flow string size on the horsepower required to lift the reservoir fluid. In designing gas-lift installations for flow through annulus, it is desirable to know the variation of pressure with depth for the injection of gas in the tubing. An equation previously developed for the upward flow of gas in tubing has been rearranged so that the pressure traverse for vertical flow downward can be calculated.[11]

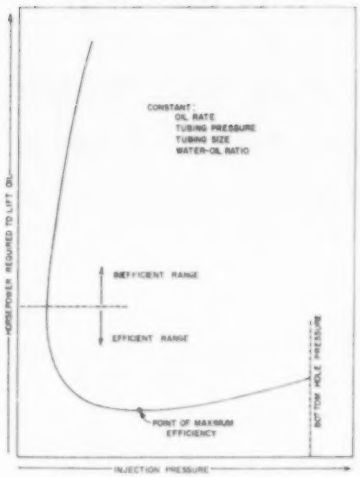

FIG. 8. **Effect of injection pressure** on horsepower requirements. Point of maximum efficiency coincides with minimum horsepower.

$$L = \frac{L_s}{\dfrac{2.94409 \times 10^{-8} Q^{1.935} G^{1.935} L_s^{\,2}}{D^{5.058} \mu^{0.065} (\Delta P)^2} - 1} \quad \ldots\ldots\ldots\ldots\ldots (10)$$

R. V. Smith[12] has also presented an equation for upward flow of gas in tubing. This equation can also be rearranged so that the pressure traverse for downward flow of gas can be calculated:

$$e^s P_w^{\,2} - P_s^{\,2} = \frac{0.1 f Q_g^{\,2} T^2 Z^2 (e^s - 1)}{0.0375\, d^5} \quad \ldots\ldots\ldots\ldots (11)$$

Either of the above equations can be used to calculate the gas pressure at the well head to lift the reservoir fluid and also to determine the pressure drop across the tubing and annulus, knowing the wellhead pressure. It is of interest to note the possibility of either a positive or negative pressure gradient for the downward flow of gas. At low flow rates, the gradient is positive, whereas at high gas flow rates, it is negative. This is explained by the fact that as the flow increases, the energy loss increases and can only be overcome by a decrease in the change of compression energy or PV energy of the system. The potential energy due to elevation is constant and the change in kinetic energy is usually negligible.

Application of Correlation

The use of the correlation as applied to annual flow can best be explained by the solution of a typical example problem:

Example problem. It is desired to gas-lift a well by flowing through the annulus. The well has a productivity index of 10.0 bbl of total liquid per day per psi pressure drop. The static reservoir pressure is 3800 psia at a well depth of 10,000 ft. The water-oil ratio is 18.33. Other pertinent information is:

Tubing ID (2½" nominal; 6.5 lb/ft)	= 2.441 in.
Tubing OD (2½" nominal; 6.5 lb/ft)	= 2.875 in.
Casing ID (7" nominal; 26 lb/ft)	= 6.276 in.
Casing pressure	100 psia
Average flowing temperature in annulus above injection depth	155 F
Average flowing temperature in annulus below injection depth	185 F
Average flowing temperature in tubing	140 F
Gravity of stock tank oil at 60F	0.8390
Gravity of separator gas (air = 1.0)	0.625
Gravity of produced water	1.15
F (formation volume factor)	$0.0000723 P + 1.114$
S (gas solubility)	$0.1875 P + 17$
Formation gas	600 cu ft/bbl of oil

(a) Calculate the variation of injection gas-oil ratio with injection pressure, and injection depth for a total liquid production rate of 4000 bbl per day. Calculate the horsepower requirements to lift the oil as a function of injection pressure.

(b) Calculate the injection gas pressure necessary at the well head for the various gas rates of Part (a) above, assuming no pressure drop across the tubing and annulus.

Solution. The solution to this problem involves the following steps:

1. Calculation of the pressure gradients below the point of gas injection.
2. Calculation of pressure gradients above the point of gas injection for various injection gas-oil ratios.
3. Simultaneous solution of (1) and (2) to determine the depth of injection for various injection gas-oil ratios and a casing pressure of 100 psia.
4. Calculation of the theoretical adiabatic horsepower required to compress the gas from 100 psia to the injection point pressure.
5. Calculation of wellhead pressures required for the gas flow downward through the tubing to the injection depth.

The first step in Part 1 of the solution to this problem was the calculation of the flowing density of the three-phase fluid produced into the well as a function of the pressure. Using Fig. 5 of this report, the differential pressure gradients were then determined as a function of fluid density and, therefore, pressure. These results were then placed on a plot of 1/dp/dh v P. The depth traveled by the fluid flowing from the bottom-hole pressure to any lower pressure was determined by integrating this curve. In this way, the curve "A" in Fig. 9 was determined.

Part 2 of the solution was carried out mechanically the same as Part 1 with the exception that the fluid densities were calculated for injection gas-oil

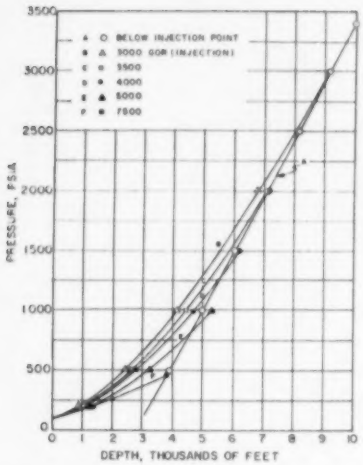

FIG. 9. **Pressure versus depth** for several values of injection gas-oil ratio.

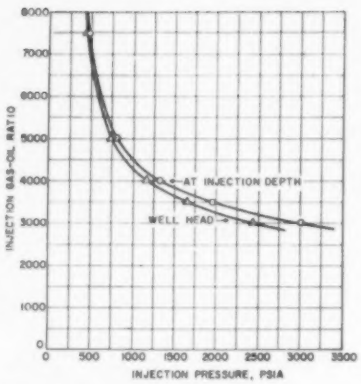

FIG. 10. **Variation of injection gas-oil ratio** with injection pressure, for an example total liquid production rate of 4000 bbl per day.

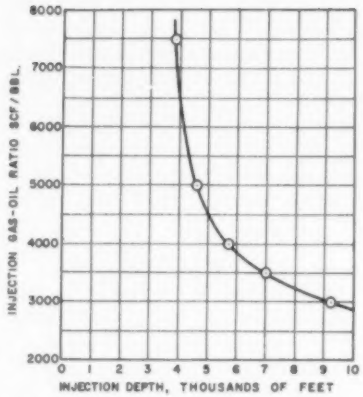

FIG. 11. **Relationship between injection depth** and injection gas-oil ratio.

ratios of 3000, 3500, 4000, 5000, and 7500 std cu ft per bbl, and that the integrations were carried out from the wellhead casing pressure of 100 psia to the pressures farther down the casing. The results of these calculations are shown in Fig. 9 as Curves B, C, D, E, and F. The intersections of these curves with Curve A represent the injection points for these flow rates and injection gas-oil ratios.

The solutions to Part (a) of this problem are further shown in Fig. 10, where the injection gas-oil ratio has been plotted as a function of the injection pressure at injection depth. For the conditions of this example problem, it will be noted that the injection pressure continually decreases as the gas-oil ratio is increased from 3000 to 7500 std cu ft per bbl.

Fig. 11 shows the relationship between injection depth and injection gas-oil ratio. This plot shows that as the injection gas-oil ratio is decreased, injection point is moved down the hole.

Fig. 12 shows the theoretical adiabatic horsepower required to compress the injected gas between injection pressure and the surface pressure. For the conditions of this problem, the minimum horsepower is required when the injection point is at the bottom of the well, although as pointed out in the earlier discussion, it is theoretically possible to obtain minimum horsepower requirements at points other than at the bottom of the hole.

Part (b) of the problem was solved using Equation 11 for the downward flow of gas through pipe. The results of the calculations are given in Fig. 10 as the curve labeled "well head." For the injection rates investigated, the overall pressure gradients in the tubing are always in the direction of the static gradient, although as pointed out in earlier discussion, for high injection rates the direction of this gradient may be reversed.

Nomenclature

P = Absolute pressure in consistent units
h = Height above datum plane, ft
W_f = Energy losses due to irreversibilities of the fluid in flow such as slippage or liquid hangup, frictional effects due to surface of the tubing, change in surface areas between the mixture of liquid and gas flowing in the tubing, combinations of any of these plus any other effects
V = Specific volume of flowing fluids, in cu ft per lb
v = Velocity of flowing fluid in ft per sec
W_s = Work done by fluid while in flow (similar to shaft work in driving a turbine)
D = Inside diameter tubing, ft
D_o = Outside diameter tubing, ft
D_i = Inside diameter casing, ft
f = Dimensionless correlating function
V_m = Cu ft of mixed gas, oil, and water at pressure P per bbl of stock tank oil, based on the ratio of fluids flowing in and out of flow strings

$$V_m = 5.61F + \frac{P_b T_a Z}{P T_b}(S_{g/o} - S_s) + V_w$$

F = Formation volume factor of oil at pressure P, bbl reservoir oil per bbl stock tank oil
$S_{g/o}$ = Producing gas-oil ratio, cu ft per bbl of stock tank oil
S_s = Solubility of gas in oil at pressure P, cu ft per bbl oil
V_w = Cu ft of water produced per bbl of stock tank oil
P_b = Base pressure at which gas is measured
T_a = Average temperature of flow, deg R
T_b = Base temperature at which gas is measured
Z = Compressibility factor of the gas in tubing at temperature T_a and pressure P
Q = Bbl of stock tank oil produced per day
M = Total mass of gas, oil, and water in lb associated with one bbl of stock tank oil flowing into and out of the flow string

$$M = (5.61)(62.4)(G_{sto}) + 0.0764(G_g)(S)_{g/o} + 62.4(G_b)(V_w).$$

G_{sto} = Specific gravity of stock tank oil
G_g = Separator gas gravity (Air = 1)
G_b = Specific gravity of produced water
ρ = Density at pressure P, lb per cu ft

Equation 10

L = Depth in ft
Q = MMcfd of gas at 14.65 psia and 60 F
G = Gas gravity (air = 1.0)
D = Diameter in ft
μ = Viscosity in lb/ft/sec ($6.72 \cdot 10^{-4}$ × viscosity in cp)

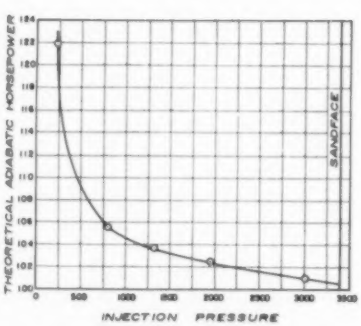

FIG. 12. **Theoretical adiabatic horsepower** required to compress injected gas between injection pressure and surface pressure.

ΔP = Pressure drop in psi

P_r = Pseudo reduced pressure, P/P_{pc}

$$L_a = \frac{53.241\ T_a}{G} \int_{P_{r2}}^{P_{r1}} \frac{Z}{P_r}\, dP_r$$

T_a = Average temperature R

Equation 11

P_s = Sandface pressure, psia

P_w = Wellhead pressure, psia (all squared pressures are expressed in thousands)

f = Coefficient of friction = $\frac{2g_c DW_f}{4v^2 L}$

Q = MMcfd at 14.65 psia, 60 F

T = Effective temperature R

Z = Effective compressibility factor of gas

d = Internal diameter, in.

e = Natural logarithm base = 2.71828

L = Length in ft

S = Exponent of $e = 0.0375 \frac{GL}{TZ}$.

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BUREAU OF MINES ANALYZES CRUDE FROM ALASKAN WELL

Oil from Alaska's newest producing area, the Swanson River region of the Kenai Peninsula, has been analyzed by the Bureau of Mines, the Department of the Interior has announced. The crude comes from the Swanson River No. 1 well, one of two commercial wells in the nation's 49th state, and was analyzed at the Bureau's Petroleum Research Center, Laramie, Wyoming.

The Swanson River oil is 30 deg gravity, containing 27 percent gasoline and only 0.16 percent sulfur, according to the Bureau. It has more than 30 percent residuum and is paraffinic in the lower fractions, suggesting its suitability for diesel fuels. It is more asphaltic in the higher fractions.

Production of the Alaska petroleum is from the "Hemlock" zone of the Tertiary age, which is found at a depth of more than 11,000 ft. It contains more nitrogen than sulfur — an unusual ratio, but one associated with Tertiary oils. This oil resembles the higher California petroleums, most of which are produced from Tertiary formations.

Oil was discovered in the Swanson River area, about 40 miles south of Anchorage, by the Richfield Oil Corporation. The No. 1 well, brought in September 29, 1957, flowed 900 bbl per day of 33 deg gravity oil and 122,000 cu ft of gas. Since October 1958 it has been producing approximately 500 bbl of 30 deg crude daily. Output is trucked to Seward by the Standard Oil Company of California, unit operator, and then moved by tanker to Standard's refinery at Richmond, California.

Additional wells are being drilled in the Swanson River area, but thus far only wells No. 1 and 2 are producing.

Previous oil discoveries in Alaska have included Katalla, on the Gulf of Alaska, near Cordova, and Umiat, in the Naval Petroleum Reserve, north of the Arctic Circle. The Katalla well produced from 1902 until 1933, when it was abandoned. Its total output was 150,000 bbl. The Umiat well has not produced commercially because of its inaccessibility. Analyses of several of these oils will be given in a Bureau of Mines Report of Investigation now being readied for publication.

Following is the Bureau's analysis of the crude from the Swanson River Field's No. 1 well:

General Characteristics

Gravity, specific, 0.878 — Gravity, deg API, 29.7 — Pour point, F, below 5

Sulfur, percent, 0.16 — Color, brownish black

Viscosity, Saybolt Universal at 100 F, 61 sec; at 77 F, 105 sec — Nitrogen, percent 0.203

Distillation, Bureau of Mines Routine Method

Stage 1 — Distillation at atmospheric pressure, 760 mm. Hg.

First drop, 79 F

Fraction No.	Cut temp, F	Percent	Sum, percent	Sp gr 60/60 F	API, 60 F	Refractive index n_D at 20 C	S.U. visc, 100 F	Cloud test, F
1	122	1.9	1.9	0.655	84.5			
2	167	2.9	4.8	.697	71.5	1.38618		
3	212	2.9	7.7	.725	63.7	1.40248		
4	257	5.2	12.9	.737	60.5	1.41024		
5	302	6.0	18.9	.756	55.7	1.41925		
6	347	4.5	23.4	.773	51.6	1.42893		
7	392	4.0	27.4	.790	47.6	1.43788		
8	437	4.3	31.7	.807	43.8	1.44685		
9	482	4.8	36.5	.822	40.6	1.45673		
10	527	6.7	43.2	.837	37.6	1.46715		
Stage 2 — Distillation continued at 40 mm. Hg.								
11	392	3.2	46.4	0.858	33.4	1.47582	39	10
12	437	5.9	52.3	.864	32.3	1.48024	45	20
13	482	5.3	57.6	.878	29.7	1.48757	56	45
14	527	4.6	62.2	.900	25.7		83	65
15	572	6.4	68.6	.912	23.7		155	80
Residuum		31.4	100.0	1.016	7.8			

Carbon residue, Conradson: Residuum, 22.3 percent; crude, 8.1 percent.

Gilsonite

FIG. 1.

. . . Unique additive for oil well cements

Knox A. Slagle and Gregory Carter
Halliburton Oil Well Cementing Company
Duncan, Oklahoma

SINCE GILSONITE, a solid hydrocarbon, was introduced to the oil industry in August 1957 as a cement additive, over 200 jobs have been performed using the material. These operations have included primary cementing through lost-circulation zones of surface, intermediate, and production pipe in both single and multiple stages as well as various remedial jobs such as squeezing, re-cementing above inadequate fill-up, and plugging back to reestablish drilling-fluid circulation. Designed primarily as a combination low-density lost-circulation slurry, gilsonite has yielded excellent results in areas of incompetent formations as well as in other types of lost-circulation zones. Field results generally show that fill-up of 80 to 90 percent can be obtained in areas where only 50 to 60 percent fill-up was possible with other types of slurries.

The unique properties of gilsonite such as low specific gravity, particle-size distribution, impermeability, resistance to corrosive fluids, chemical inertness, and low water requirements result in a slurry having exceptional bridging properties, low slurry weight, compatability with other slurry additives, and relatively high compressive strength when compared to other slurries of the same weight.

Need For Better Slurry

As the oil-producing industry has continued to grow, the need for a low-density cementing slurry possessing lost-circulation control characteristics has become more and more evident. This is especially so in primary cementing because of the different types of formations being encountered and the need to reduce remedial cementing operations. These problem formations may range from either porous or cavernous formations to very weak formations that are unable to support the hydrostatic head that is necessary for drilling and well completion. This latter type of formation will often break down or fracture under hydrostatic loading, resulting in partial or complete loss of circulation.

Lost-circulation zones encountered during drilling operations may produce many problems in the normal course of completing a well. Increased expenditures can result from reduced drilling rates, fishing jobs, and other mechanical difficulties as well as from loss of large volumes of drilling fluid. Sometimes severe lost-circulation problems may even cause abandonment of a well.

Lost circulation during cementing operations will often be reflected by inadequate fill-up in the annulus and the consequent displacement of slurry into formations away from the well bore. Satisfactory isolation of the different formations may then require re-cementing work above the point of loss and subsequent squeeze-cementing jobs. Inasmuch as rather extensive information has been published[1,2,3] on lost circulation while drilling, these investigations have been directed primarily to the second phase, lost circulation while cementing although there is some overlapping in areas where cementing slurries with excellent bridging properties may be used advantageously to restore mud circulation.

Present Additives

Attempts have been made to restore circulation while cementing using many types of materials. Sometimes sufficiently good results have been obtained simply by reducing the slurry density

What Is Gilsonite?

Gilsonite is a relatively new and unique additive for the oil industry's use to combat lost-circulation conditions. This material is a solid hydrocarbon that occurs principally in the Uintah Basin of Utah and Colorado. These are not only the largest deposits in the world, but also the most extensively developed. It was discovered in 1885 by Captain Samuel Gilson, hence the name of the material, gilsonite. It has been generally grouped as a form of native asphalt, but its unusual properties made it markedly different from the bitumens or asphalts which may range from liquid to definite solid form whether native or processed. Gilsonite is mineralogically classified as an asphaltite. This material was deposited in roughly parallel lines running from a northwest to a southeast direction and it occurs in vertical fissures rather than in beds, pools, or lakes where the bitumens and asphalts are found.

Gilsonite's properties make it valuable for both heat and electrical-insulation applications. Floor tile, roofing materials, acid-resisting paints, electrical-insulating varnish, battery boxes, and brake and clutch linings all contain finite quantities of gilsonite. It is used in underbody coatings for cars, printing ink, and other items where its black color can be used to advantage.

Presented at the Spring Meeting of the Pacific Coast District, API Division of Production, Los Angeles, California, April 30 - May 1, 1959.

whereas other instances have occurred where bridging materials were found to be most helpful, but there still remained zones of loss which would not react satisfactorily to either of these methods. Combinations of these two approaches have also been utilized, but it has been difficult to obtain optimum bridging and density without sacrificing other desirable slurry properties such as strength and resistance to corrosive fluids. Some of the more commonly used additives in this application should be mentioned briefly.

Bentonite. One material which has been used quite extensively is bentonite in concentrations from 0 to 12 percent by weight of the cement. The primary purposes of bentonite in cement are to decrease slurry weight and increase slurry volume. These properties are obtained because of the ability of bentonite to absorb relatively large amounts of water. This water, in excess of that required for the cement reaction, substantially reduces the strength of the cement and contributes to the lower resistance of this type of slurry to detrimental down-hole conditions such as corrosive waters and high temperatures.

DE. Diatomaceous earth is another material that is principally used as a light-weight additive. Because of its extremely high surface area, large quantities of water are required to produce a pumpable slurry, with a resultant low compressive strength.

Shells, plastic, cellophane. Actually even though these materials reduce the strength of cement, they will generally provide adequate strength for normal cementing operations. Their prevalent disadvantage for use in lost-circulation zones is the lack of coarse bridging particles. Incorporation of coarse additives into these slurries is possible, but may further reduce the compressive strength beyond that which is desired when sufficient quantities are used to effectively control lost returns in relatively severe areas. Materials such as ground nut shells, granulated plastics, and cellophane flakes have been used as bridging agents with excellent results where lost-circulation problems were of a relatively minor nature, but they have not been too successful where major difficulties were encountered.

Pozzolan. Moderate slurry-weight reduction can be attained by the use of pozzolanic additives with cement. Because a pozzolan reacts with the hydrated lime from the cement to yield cementitious compounds, relatively good strengths are realized and bridging materials may be used with this type of slurry to provide additional benefits.

Expanded perlites. Expanded perlites have been used in the oil industry since 1951 for both lost-circulation control and moderately light slurry weight, although in order to have a pumpable slurry extra mixing water is required. The reason for the additional water is that the expanded perlite contains small air cells and when subjected to pressure in a well the walls of these cells will break down and accept water from the slurry, causing a slight dehydration which might result in reduced pumpability if inadequate mixing water were used.

All these various types of slurries which have been discussed briefly have shown ability to control lost-circulation problems under some limited conditions and certain areas of the country may obtain adequate results from their use. However, none of them have shown the overall effectiveness, particularly in the severe lost-circulation zones, that has been exhibited thus far by the use of gilsonite.

Laboratory Investigations

Gilsonite was first evaluated as a density-reducing additive for cementing slurries because of its low specific gravity (1.07). Laboratory testing was set up to establish an optimum particle size for these applications with three primary points being considered:

1. Maximum size to permit pumping through down-hole cementing equipment such as float collars and multiple-stage collars.
2. Minimum size to provide excellent control of lost-circulation zones.
3. Proper particle size distribution to obtain the two preceding objectives and to allow slurry preparation with a minimum amount of mixing water.

Physical properties of the material ultimately selected are shown in Table 1. Fig. 1 shows the appearance and even distribution of gilsonite in a set-cement sample.

Lab Tests

Further laboratory tests were then instigated to determine the validity of these concepts, particularly compressive strength, compatibility with other additives, lack of porosity of the gilsonite, and the effectiveness in sealing porous or fractured simulated formations. Test methods in general were those described in *API RP 10B*[4] for compressive strength and thickening time and *API RP 29*[5] for lost circulation, although slight modifications were necessary because of the granular particles.

Compressive-strength tests were conducted using various ratios of gilsonite with different basic cementing compositions under varying curing temperatures. The results of these tests are shown in Fig. 2, 3, and 4 with comparative data for other types of slurries which may be used in similar applications. It can be seen that at equal slurry weight, higher strengths are generally attained with gilsonite, which permits the use of lower water ratios than do other low-density or lost-circulation-control additives.

Thickening-time tests were made on the Pan American high-pressure thickening-time tester at simulated well depths of 8000 and 10,000 ft to determine the effect of gilsonite on the pumpability of neat cement, and cement containing bentonite, a calcium lignosulfonate retarder or a pozzolanic additive. There was virtually no difference in thickening times of these slurries containing 0 or 50 lb of gilsonite per sack, as shown in Table 2, indicating the chemical inertness of gilsonite and the practicality of using other additives in conjunction with it.

Another series of compressive-strength tests was made using gilsonite with calcium chloride as an accelerator. It was found that acceleration of compressive-strength buildup was obtained in about the same order of magnitude, percentagewise, as occurs with other types of cementing slurries.

Density measurements were made on set specimens cured under 0 and 3000 psi pressure to measure any difference which would result from com-

TABLE 1. Physical Properties of Gilsonite.

Specific gravity	1.07
Bulk density, lb per cu ft	50
Water requirement, gal per bulk cu ft	2 (approx.)
Melting point, deg F	385 to 525

Following selection of a gilsonite for use in cement slurries and further study of the material itself, it was anticipated that the following advantages could be attained.

1. Low slurry densities because of the specific gravity of the solid gilsonite rather than because of addition of large volumes of water.
2. Higher compressive strengths at a specific slurry weight by virtue of adding solid particles instead of adding water.
3. Compatibility with existing retarders, accelerators, low-water-loss materials and other slurry additives inasmuch as the solid hydrocarbon would be chemically inert in a cement system.
4. Protection against premature dehydration of the slurry because the gilsonite is impermeable and nonporous.
5. Equal or superior resistance to corrosive waters because the material itself is chemically resistant to both acidic and alkaline solutions.
6. Excellent control of lost-circulation zones with a granular bridging material strong enough to withstand moderate squeeze pressures and yet soft enough to permit pressure deformation providing an effective seal against loss.

FIG. 2.

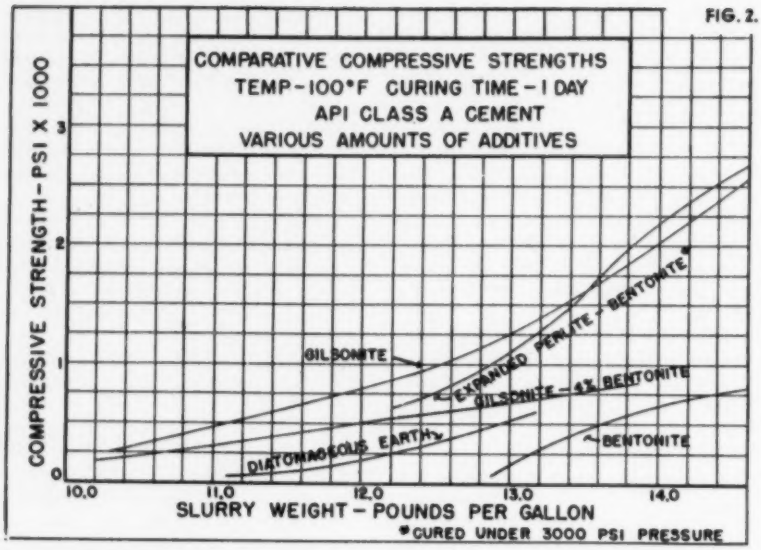

FIG. 3.

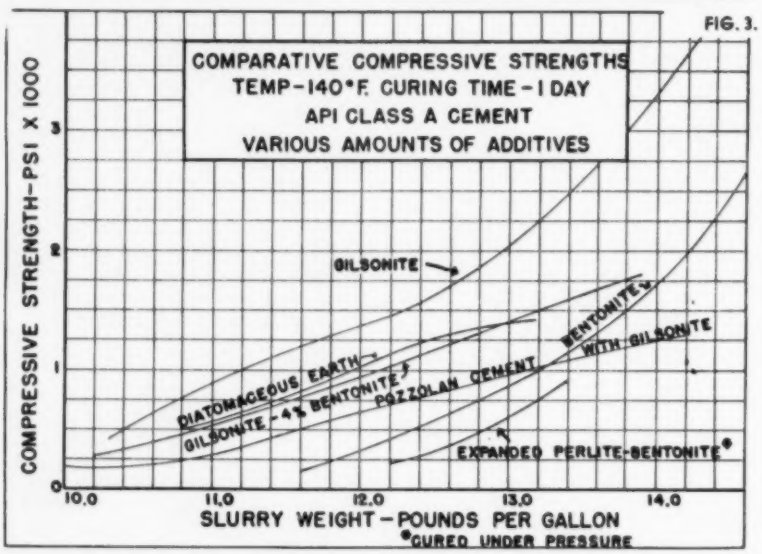

FIG. 4.

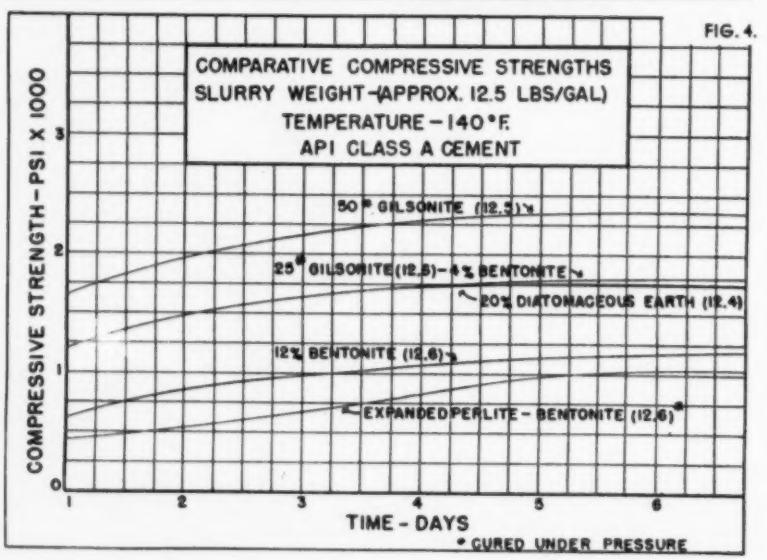

FIG. 2, 3, 4. Results of compressive strength tests using various ratios of gilsonite, and compared with other forms of cement slurries.

pression of air in void spaces and indicate porosity within the particles of gilsonite. There were no measurable differences discovered in this group of tests thereby leading to the obvious conclusion that no voids exist within the gilsonite particles.

The ability of gilsonite to control lost-circulation problems was tested by the two general methods outlined in *API RP 29*.[5] Effectiveness in porous formations was measured on a graded-limestone gravel bed having a permeability of approximately 450 darcys while fractures were simulated by use of slots of various widths machined in metal slugs.

Complete duplication of field conditions existing in lost-circulation zones is very difficult and the results of these tests are not to be construed as absolutely valid data with respect to what volume of loss might be expected in a well. However, as a comparative method for evaluating lost-circulation materials the gravel bed has been found to be useful from the standpoint that a material which performs best during the tests will generally provide superior results in the field.

Table 3 shows a portion of the data obtained during these tests comparing gilsonite to expanded perlite, an additive which has probably been more widely used as a bridging agent to reduce slurry loss than any other prior to the introduction of gilsonite. As concentration of the additives was increased, the gilsonite definitely permitted less loss of slurry and in actual field usage gilsonite has also been superior in providing maximum fill-up through lost-circulation zones.

Laboratory tests have also been performed to determine the effect of various oils on gilsonite cement since the gilsonite itself, being a hydrocarbon, is soluble to a certain extent. It has been found that gilsonite is more soluble in solvents such as kerosine and naphtha than it is in various crude oils which were available for conducting tests. Tests were then made wherein a gilsonite cement column was placed in the annular space between 1-in. and 3-in. pipe and cured for 3 days; a hole was drilled through both pipes and the cement, and kerosine was pumped through the simulated perforation for a measured period of time at 4 gal per min. The samples, after testing, were sawed in two and the results of one such test are shown in Fig. 5. During the limited time of the test there was no detrimental effect noted on the cement, and there was only a slight dissolving of exposed gilsonite particles.

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TABLE 2. Thickening-Time Tests API Simulated Casing Schedules.

Test Depth Feet	Percent Calcium Lignosulfonate	Hours: Minutes Thickening Time at Indicated Gilsonite Concentrations*	
		0	50
API Class A Cement			
Slurry density, lb per cu ft (lb per gal):		116.7 (15.6)	93.5 (12.5)
8,000	0	1:44	1:48
10,000	0.3	2:08	2:16
API Class A Cement—4-percent Bentonite			
Slurry density lb per cu ft (lb per gal):		105.5 (14.1)	89.8 (12.0)
8,000	0	1:44	1:40
Pozzolan—Cement			
Slurry density, lb per cu ft (lb per gal):		106.0 (14.2)	87.5 (11.7)
8,000	0	2:08	2:14
10,000	0.3	2:45	2:46

*Slurry loss expressed in cubic feet per square foot of formation area.

TABLE 3. Lost Circulation Tests Using API Class A Cement.

Formation Characteristics:
Graduation — ¼ to ½-in. crushed limestone
Permeability—approximately 450 darcys
Differential pressure at shut-off—1000 psi

Cu ft of Additive per Sack of Cement	Total Slurry Loss Before Shut-off* Gilsonite	Expanded Perlite
1/8	0.424	0.456
1/6	0.363	0.406
1/2	0.245	0.492
1	0.291	0.458

*Slurry loss expressed in cubic feet per square foot of formation area.

It is anticipated that there will be very little effect beyond the exposed particles of gilsonite because of the cement boundary between particles, but further testing is being considered for longer periods of time and at higher temperatures than the room temperature used during this first series of tests.

The effect of high temperatures with regard to softening and aglomeration of the gilsonite has also been studied. Up to temperatures of 240 F, with pure gilsonite being tested, there was no apparent sticking together of the separate particles, indicating no appreciable softening of the material. Because of the temperature reduction during circulation, there should not be any formation of a plastic mass while circulating gilsonite at bottom-hole static temperatures of 300 F or slightly above.

Fig. 6 is a bar graph showing slurry weight and slurry-volume data for three types of cementing slurries containing various quantities of gilsonite. As would be expected inasmuch as the specific gravity of gilsonite is very nearly the same as that of water, almost identical slurry factors are obtained upon the addition of gilsonite as would be obtained with the addition of an equal weight of water. Volumewise 1 bulk cu ft of gilsonite (50 lb) plus the 2 gal of mixing water occupies 1.02 cu ft so that slurry yield with this additive is relatively high for each sack of cement used.

Field Results

Gilsonite has been used in nearly all areas of the country for many different cementing operations. Table 4 lists the types of jobs performed in the various areas. The amount of gilsonite used on these jobs in respect to the type of cementing composition and other additives is given in Table 5.

A discussion of the different types of jobs in the various areas and a summary of the various well conditions encountered in the different locations where gilsonite cement and other types of cement compositions have been used should be of benefit in assessing the potential value of this additive.

Oklahoma. In the Oklahoma area most of the gilsonite-cement jobs that have been performed were squeeze jobs to correct inadequate fill-up. In one southern Oklahoma field a 1500 psi dry test was obtained after a squeeze job using 25 lb of gilsonite per sack of API Class A Cement with a low-water-loss additive and an accelerator. This successful repair job followed six other attempts with various types of cementing compositions during which it was impossible to attain a satisfactory squeeze pressure.

Since this initial success, four other wells in the same field which were reported after Table 4 was prepared have

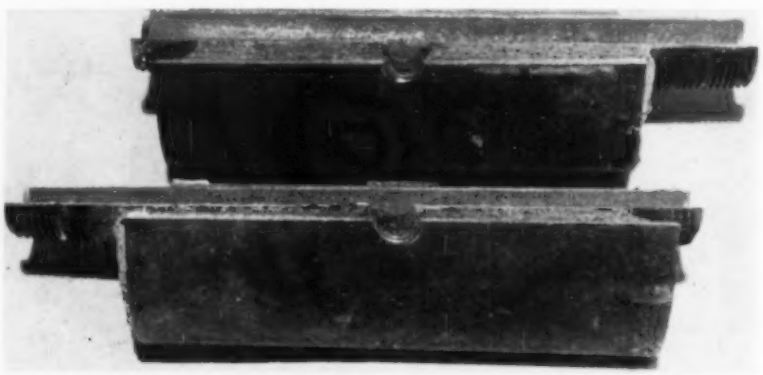


FIG. 5. **Effect of kerosine** and naphtha on lab samples of 100 lb gilsonite/sack cement with 9 gal of water per sack. The sample was cured in water for 3 days at 140 F; flowed kerosine through sample for 120 hours. Only "slight" dissolving was noted.

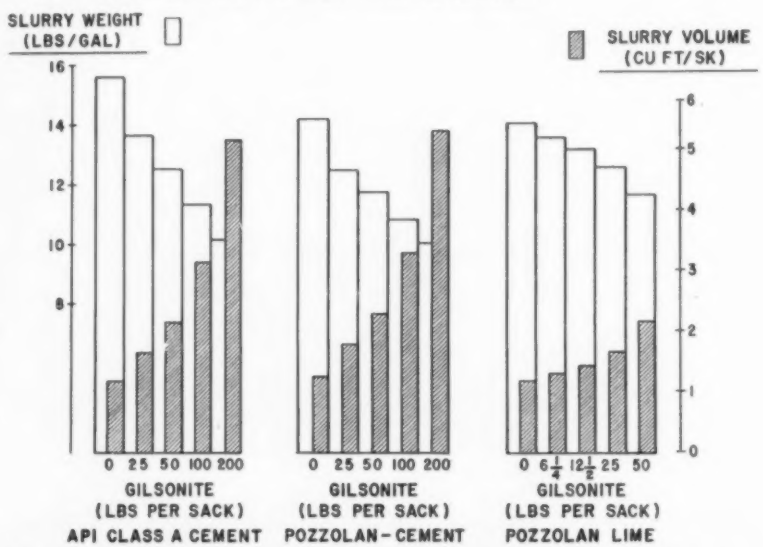


FIG. 6. **Slurry-weight and slurry-volume data** for three types of cementing slurries containing various quantities of gilsonite.

been satisfactorily squeezed on the first attempt using the gilsonite cement with squeeze pressures of 2000 to 4500 psi. These jobs were in a rotten-shale section and consideration is now being given to using gilsonite cement for primary cementing in an attempt to avoid the remedial jobs. In another field one zone in a well was to be isolated for salt-water disposal. After three unsuccessful attempts, with 100 to 150-sack batches of API Class A Cement with a low-water-loss additive each time, to obtain squeeze pressure through the perforations a blend of 15 lb of gilsonite per sack of cement plus a low-water-loss additive was tried and a pressure of 4000 psi obtained after 15 sacks were displaced into the formation. Excess cement was backwashed and the squeeze tested to 3000 psi. After cement had set under 1500 psi pressure, no cement was found inside the pipe and the perforations were tested to 3000 psi without any leaks.

Other squeeze jobs have also been satisfactorily performed with gilsonite cement after 2 to 5 failures with other types of cements, and as a consequence interest has definitely increased in the potential value of 10 to 25 lb of gilsonite per sack of cement for this type of application.

Texas. Only a few gilsonite cement slurries have been used in the north central Texas area inasmuch as lost circulation has not been a serious problem, but there was one very interesting operation performed. Insufficient fill-up was obtained on the primary-cementing job without gilsonite so 8 perforations were placed in the casing over a 2-ft interval above the top of the cement at approximately 3850 ft. A pozzolanic-cement slurry containing 100 lb of gilsonite per sack and mixed at 10.8 lb per gal was circulated through these perforations to approximately 2700 ft where a split was found in the 5½-in. casing. The packer was then raised above this split and the remaining slurry displaced at this point to bring the cement column to 2100 ft. The upper stage was overdisplaced with 5 bbl of water and the split casing was later repaired by squeezing. A significant observation from this job was that a relatively high concentration of gilsonite was successfully pumped through 8 perforations and through a split in the pipe without any premature bridging.

Arkansas. In southern Arkansas there is a field which has from 2 to 5 gas pays and usually requires the use of a two-stage cementing collar plus considerable squeeze work to get proper fill-up and allow separate fracturing of each zone. Three gilsonite-cement jobs with a pozzolan-cement blend have been done in this area without the benefit of a stage collar and with adequate fill-up being obtained and no squeezing required to segregate the producing intervals. Other jobs in this general area have utilized gilsonite for its bridging effect in squeeze cementing, with all jobs reported thus far being achieved satisfactorily.

TABLE 4. Type of Jobs and Areas Where Performed.

Areas	Total Jobs	Production[1]	Intermediate[2]	Surface[3]	Squeeze	Plug-back	Recement[4]
Oklahoma	10	1	1	—	6	2	—
Illinois-Indiana	4	—	—	—	1	3	—
Rocky Mountain	5	1	—	1	—	—	3
Central Texas	2	—	—	—	1	1	—
N. Louisiana-Mississippi	6	4	—	—	2	—	—
East Texas	4	—	—	—	1	2	1
West Texas	28	14	2	—	3	8	1
Texas Gulf Coast	28	—	—	3	—	25	—
South Louisiana	24	2	4	18	—	—	—
New Mexico	15	10	1	1	—	3	—
Kansas-Texas Panhandle	74	31	4	3	15	18	3
Total	200	63	12	26	29	62	8

[1]Production casing jobs including primary cementing and liner cementing.
[2]Intermediate casing, primary cementing.
[3]Surface and conductor casing, primary cementing.
[4]Displacing slurry above existing cementing job to obtain adequate fill-up.

TABLE 5. Materials Used for Gilsonite Cement Jobs.

Type of Basic Cementing Composition	Lb of Gilsonite per Sack						
	6–24	25–49	50–74	75	100	200	Additives*
API Class A Cement	6	42	20	14	5	1	41
API Class C Cement	—	—	4	—	—	—	1
API Class E Cement	—	3	—	—	—	—	2
Bentonite cement	—	13	4	3	1	1	9
Pozzolan-cement	11	45	17	3	2	—	20
Pozzolan-lime	2	3	—	—	—	—	2
Total	19	106	45	20	8	2	75

*Other additives used included: accelerators, retarders, low-fluid-loss additives, diatomaceous earth, salt-water slurries, and other lost-circulation materials.

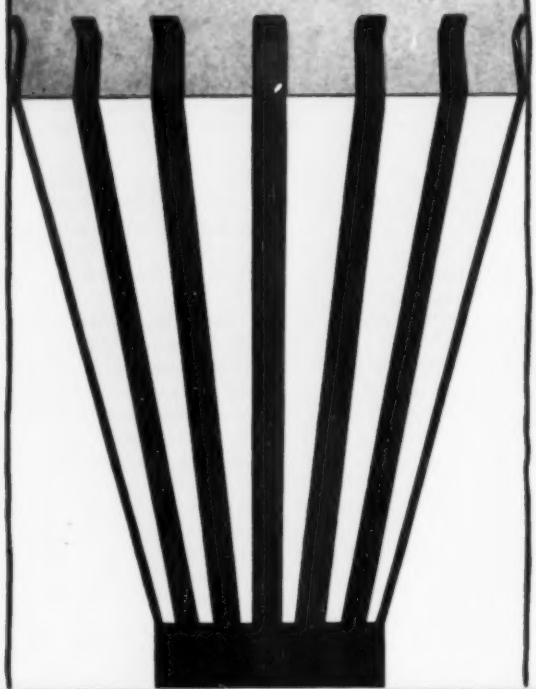
Texas Gulf Coast. The Texas Gulf Coast area has primarily used this material for plugback operations for lost circulation in fractured and faulted formations where several wells have been lost. Very good results have been obtained in restoring circulation. In another field gilsonite slurries have been the only type which would permit circulation while setting surface and conductor pipe.

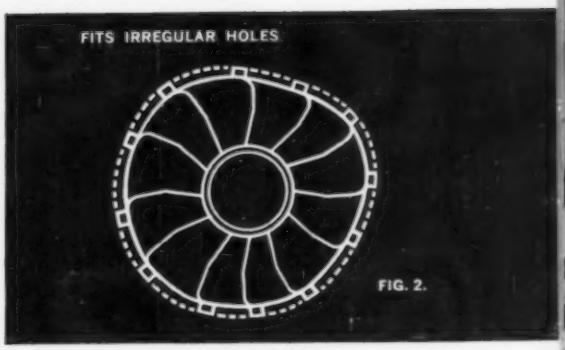
West Texas. West Texas is a notorious area for lost-circulation problems and gilsonite has contributed materially to successful cementing operations in this area. In one field considerable trouble is encountered when setting production pipe because of two very weak formations. Prior to the introduction of gilsonite all types of bridging materials and lightweight slurries had been tried with at least two or three stages being required. Most of these jobs showed fluctuations in pressure while pumping which indicated the breaking down of the weak formations while cement was being circulated. Five single-stage jobs have been reported using gilsonite with a steady buildup of pressure from the time cement reaches the formations until the top plug was landed. Temperature surveys indicated fillup of 90 percent or better on each of these jobs whereas other types of slurries required more slurry volume and staging in order to attain this fillup.

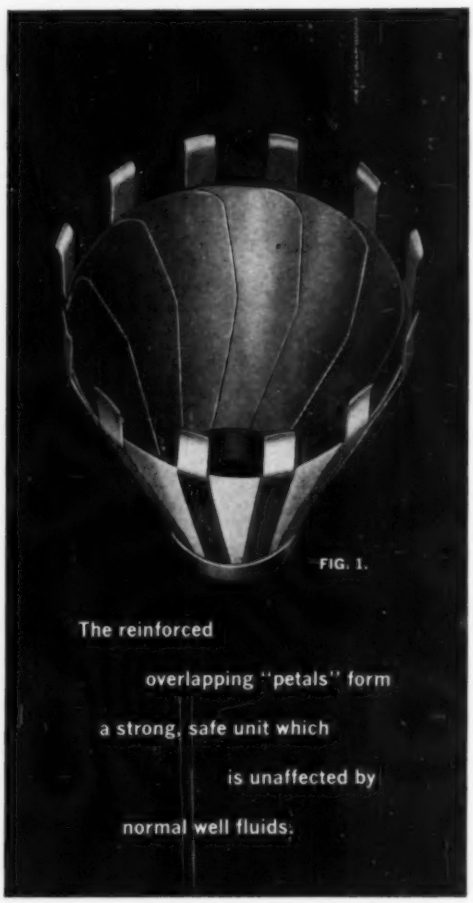
New Mexico. The majority of the jobs in the New Mexico area using gilsonite cement have been setting production liners in gas wells where extremely weak formations exist. The first two jobs run in this area were on gas-drilled wells at a depth of approximately 6000 ft with a 5½-in. production liner being set in a 6¾-in. hole. Both jobs were cemented using API Class A Cement containing gilsonite. After the liner was cemented the drill pipe was raised to reverse out any excess cement slurry above the top of the liner with gilsonite-cement slurry being returned to the surface on both jobs, indicating that cement had completely circulated the liner. Calculations on both jobs indicated that only 25 to 35 percent excess volume of gilsonite cement was needed to circulate the liners compared to 200 percent excess which was used with other types of additives without being able to circulate completely because of lost-circulation zones.

In another field in New Mexico cement could not previously be circulated on a long string because of a weak coal bed lying near the top of the producing zone. The wells of this area that have been cemented using gilsonite have been very successful with gilsonite slurry being circulated out during the

keep cement where you want it!







For Problem Cementing, where a lower permeable (or weak) zone must be protected from the cement slurry, or from sloughings and cavings, the Baker METAL PETAL Basket is safe and successful.

A number of "petals" made of flexible sheet steel are mounted on reinforcing spring-steel ribs which in turn are mounted on a ring to form the Basket. This all-metal construction provides unusual strength; there is little likelihood of damage to the unit while running in the well.

Safe, Automatic Operation—While running in the well, upward pressure of the fluid (see Fig. 5) tends to close the petals, thus providing fluid passageway between the Basket and the wall of the hole, without distortion or damage to the Basket. As soon as the casing comes to rest, upward pressure by the fluid is relieved and the petals expand to contact the wall of the hole (see Fig. 6). Any tendency of fluid to move downward then presses the flexible petals more firmly against the entire circumference of the hole. Solids which are strained from the fluid serve to build a bridge inside the Basket, which is thus converted into a one-way annular packer of great strength and effectiveness (see Fig. 7).

Fits Large or Irregular Holes—The "Metal Petals" not only expand to contact the entire circumference of large-diameter holes (see Fig. 4) but also pack-off in holes of irregular shape as shown in Fig. 2. The independent action of the individually mounted overlapping petals permits successful use of Baker Metal Petal Baskets in casing programs with minimum clearances (see Fig. 3).

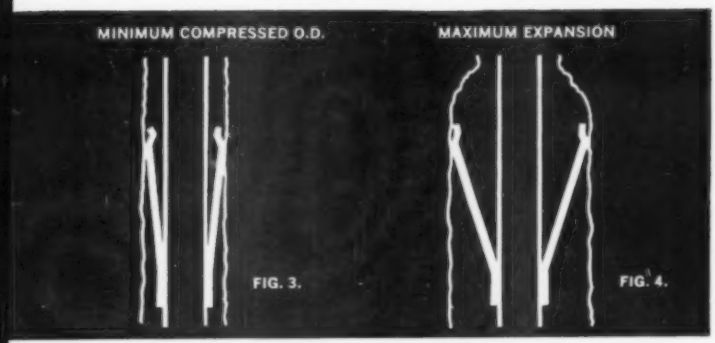
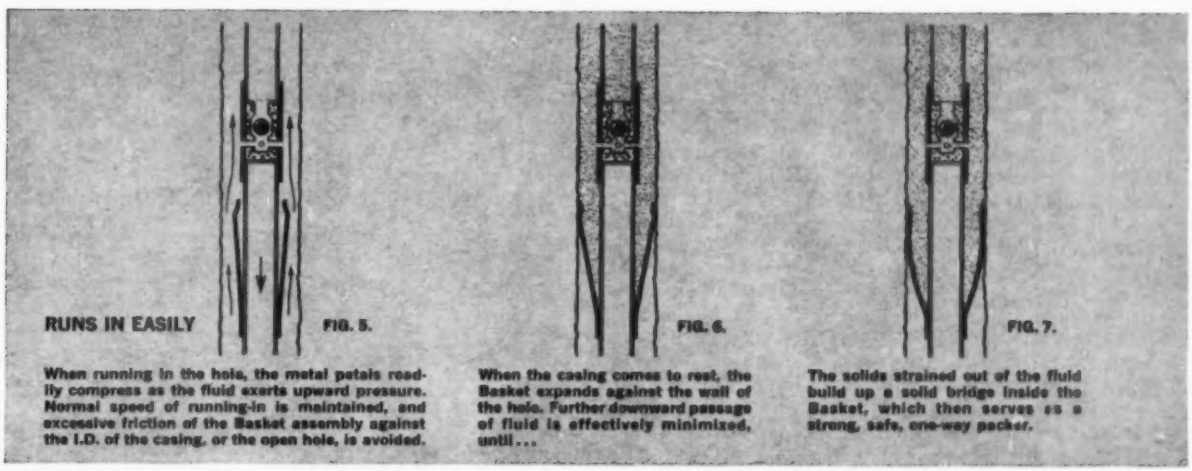


FIG. 2.
FITS IRREGULAR HOLES – The Basket expands to contact the entire circumference of irregularly shaped holes.

FIG. 3.
MINIMUM COMPRESSED O.D. – Less than ½" greater than coupling O.D. – providing ample running-in clearance.

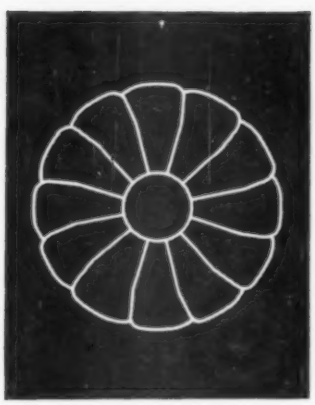
FIG. 4.
MAXIMUM EXPANSION – The Basket expands to more than twice the diameter of the casing on which it is run in sizes 5½" and larger.



When running in the hole, the metal petals readily compress as the fluid exerts upward pressure. Normal speed of running-in is maintained, and excessive friction of the Basket assembly against the I.D. of the casing, or the open hole, is avoided.

When the casing comes to rest, the Basket expands against the wall of the hole. Further downward passage of fluid is effectively minimized, until...

The solids strained out of the fluid build up a solid bridge inside the Basket, which then serves as a strong, safe, one-way packer.



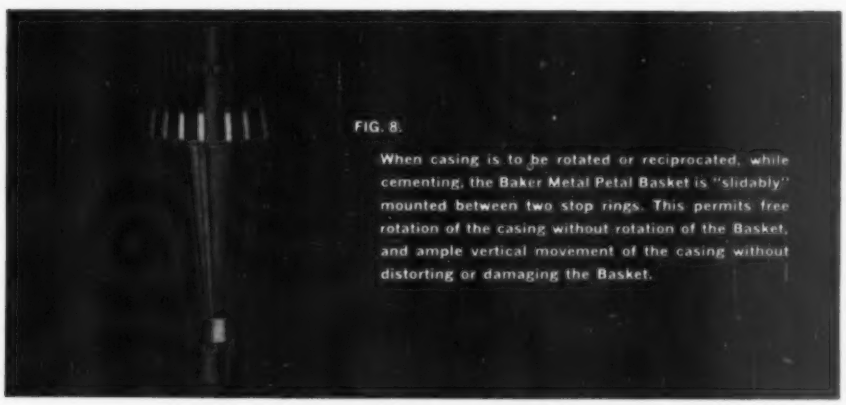


FIG. 8.

When casing is to be rotated or reciprocated, while cementing, the Baker Metal Petal Basket is "slidably" mounted between two stop rings. This permits free rotation of the casing without rotation of the Basket, and ample vertical movement of the casing without distorting or damaging the Basket.

Mountings Meet All Needs – The Baker Metal Petal Basket is furnished as a separate unit for installation to meet any requirement. Generally it is *slidably* mounted by spacing two split stop rings some distance apart to allow free travel of the Basket and free rotation of the casing. Baskets can be furnished affixed to either a *plain* or a *perforated* nipple to meet cementing requirements.

Baker Metal Petal Baskets are used extensively in combination with Baker Stage Collars to retain and support the cement slurry for the second stage. Baker Casing Centralizers are normally used above and below such combinations to provide uniform annular clearance.

Any Baker representative will give specific recommendations for the use of Baker Metal Petal Baskets; or see the BAKER (or Composite) Catalog.

BAKER

METAL PETAL BASKET

PRODUCT NO. 343

BAKER OIL TOOLS, INC.

HOUSTON • LOS ANGELES • NEW YORK

jobs indicating no loss of slurry to the thief zones.

Texas Panhandle-Kansas. A considerable amount of gilsonite has been used in the Texas Panhandle-Kansas area to combat severe lost-circulation problems caused by extremely weak or porous formations and also to provide a better cementing job where lost circulation was not a problem.

Because of the difficulty encountered from lost returns while drilling in one field, a well finally had to be shut down because the hole could not be filled with mud containing other lost-circulation materials. The fluid level was approximately 650 ft from the surface. Gilsonite cement was used to set a 7-in. casing at the depth of lost circulation and returns were established for the first time. Drilling was continued with returns being lost at four additional formations. In each instance API Class A Cement containing 100 lb of gilsonite per sack of cement was used in a plug-back-cementing operation which allowed a standing pressure of 800 to 1500 psi to be placed on each zone of loss. When drilling was resumed through each plug, complete circulation was regained. Many wells have been completed in this area using gilsonite cement where prior to its introduction some of the holes had to be abandoned because of the severe lost-circulation formations encountered.

Nine wells have been completed in another field using a pozzolan-cement mixture containing gilsonite in concentrations of from 25 to 30 lb per sack of the pozzolan-cement blend. Nearly every well in this field will be completed in two producing zones, which are either broken or fractured limestone embedded in fairly thick, rotten-shale sections. Prior to the use of gilsonite, lost returns had not been as great a problem in setting of the production string as has been communication between zones caused by the channeling of the cement slurry or deterioration of the shale formation's strength by fresh water from the slurry during cementing. Consequently every well had to be block squeezed to isolate the pay zones for fracturing and acidizing. Because of the scouring action of the gilsonite in the cement slurry, it appears to be helping remove the filter cake in the annulus during cementing. Nine wells have been completed in this field using gilsonite cement and each has been successful in that no block squeezing was required either before or after fracturing and acidizing.

Since this particular application has only recently been brought to our attention, we have been unable to secure laboratory data to support the field performance prior to preparation of this paper. However, testing is currently under way to provide more information along this line.

Fifteen unsuccessful squeeze jobs were performed on another well using many types of cementing slurries in an attempt to seal off the perforations. It was desired that the perforations should hold a standing pressure of 3000 psi after drilling out. When the well was squeezed using a gilsonite slurry, the perforations held a standing pressure of 2500 psi after drilling out; however, it failed to hold a pressure of 3000 psi. Another squeeze job was performed successfully against the existing gilsonite cement with a standing pressure of 3000 psi being attained. Although this gilsonite-cement squeeze job itself did not hold the desired pressure in this particular well, it did provide sufficient strength and bridging action for a second squeeze job to be successful where 15 previous squeezes were of no benefit.

Results of 100 Jobs

Field results on over 100 primary-cementing jobs indicate that in lost-circulation areas where only 50 to 60 percent fill-up can be attained with other types of light-weight or lost-circulation additives, 80 to 90 percent fill-up can be realized by the use of gilsonite in a cementing slurry. Also it has been found that 25 to 50 lb of gilsonite per sack of cementitious material will generally be an optimum amount for controlling lost-circulation zones and that, where weak formations exist, the bridging properties of gilsonite will allow use of 93.5 to 101.0 lb per cu ft (12.5 to 13.5 lb per gal) slurry weights for excellent cementing results whereas other types of slurries have not been satisfactory even at much lower weights.

In most areas where gilsonite has been used it appears that its scouring action is very good in removing drilling fluid and filter cake from the hole, resulting in a better cementing job without the necessity of block squeezing. This information has been derived from field reports which indicate that squeeze jobs have not been required when gilsonite cement was used for primary cementing in an area where squeeze cementing had previously been necessary for satisfactory producing-zone isolation. In other areas where this material has been used there have been no reports of squeeze operations on a gilsonite-cement primary-cementing job. Laboratory research has been instigated to evaluate more fully the advantage of gilsonite in this respect.

Both laboratory and field data show that gilsonite is compatible with existing cementing compositions and additives and the only precautions necessary are to minimize the use of high water-ratio additives which may materially reduce the strength and durability of the gilsonite blends. Accelerators, retarders, and low-water-loss additives can and should be used when specific well conditions warrant them.

Both laboratory investigations and field results on production pipe indicate the absence of serious gilsonite-cement deterioration because of hydrocarbon solubility. Separation of individual gilsonite particles by relatively impermeable cement boundaries should prevent dissolving of gilsonite except that which is exposed by perforating.

Compressive strengths attained with gilsonite are higher than for other light-weight additives when comparison is made on the basis of slurry weight. The primary reason for this is because weight reduction is obtained by use of a low specific gravity solid rather than by large volumes of water.

Because of its excellent bridging properties, certain precautions should be recommended when using gilsonite cement. Because it does have a low specific gravity and may float and accumulate in a slurry of low viscosity, water should not be used ahead of the slurry because of potential dilution and viscosity reduction. The preferred fluid ahead of gilsonite would be a mixture of bentonite and water (300 lb per 15 bbl). The slurry should also be mixed at the recommended weight throughout the job.

Because of the advantageous scouring action of gilsonite in mud removal and the possibility of premature bridging, it is also believed that a bottom-cementing plug should not be necessary and that the use of wall-cleaning devices should be held to a minimum to reduce possible restrictions in the annulus. This is not intended to imply that wall scratchers are unnecessary nor that they must be removed to allow circulation of gilsonite. Gilsonite has been pumped without complication into annuli containing scratchers, and this is primarily a warning against too-close spacing of these devices over exceptionally long intervals of pipe.

Acknowledgment

The authors wish to express their appreciation to the management of the Halliburton Oil Well Cementing Company for permission to prepare and publish this paper.

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★ ★ ★

CORROSION CONTROL AT GRAND ISLE

Freeport Sulphur prepares corrosion protection of 15,000 tons of steel in mile-long structure at world's first offshore sulfur mining plant

A. E. Hiller
Chemical Engineer, Freeport Sulphur Company, New Orleans, Louisiana

PROBLEMS of corrosion control at offshore operations have been faced by many oil companies, but few can compare with those now being tackled by Freeport Sulphur Company in constructing the world's largest steel island off the coast of Louisiana.

Freeport is in the midst of erecting a tower and bridge structure which eventually will stretch a total of one mile over 50-ft deep waters seven miles from the nearest land. The $30,000,000 project, known as Grand Isle, will mine sulfur from a depth of 2000 ft. It is scheduled to be in operation in 1960.

The structure will be composed of 5 large and 10 smaller steel towers, connected by 200-ft long bridge spans. This will support the complex and heavy facilities required by the Frasch process whereby sulfur is melted in the underground formation by superheated water and brought to the surface by compressed air.

Steel used in the piling and other members of the structure is not in itself resistant to the corrosion of the sea-water or the salt-air environment. There are three different corrosion environments which must be guarded against: The totally submerged zone, the splash zone which lies immediately above, and the salt-air zone.

Splash Zone

Of these three zones, the splash zone is the most susceptible to corrosion and the most difficult to protect from corrosion. This zone is usually defined as that section with a lower limit of −1 to −2 ft mean Gulf level and an upper limit of +5 to +8 ft mean Gulf level.

Susceptibility to corrosion in the splash zone is due to constant exposure to the combination of moisture, oxygen, and salts. The difficulty of protecting this zone is caused by the erosiveness of wave action and the shock of alternate wetting and drying.

This "problem child" of the offshore structure does not respond to most protective coatings, the method of protecting the superstructure, or to cathodic protection, the means used to prevent corrosion of the submerged sections. Corrosion engineers, wishfully thinking, have often asked design engineers to eliminate the splash zone from offshore structures.

Since the end of World War II, when oil companies began offshore exploration in the Gulf, design and corrosion engineers have come a long way in improving the methods and materials used to protect the splash zone.

The most obvious aid in effecting corrosion control in this zone is utilizing a minimum surface area design. This is done by using tubular members and making them as few in number as possible. Horizontal bracing in the splash zone is eliminated as much as is practical.

Protective Systems

Of the many types of protective measures, the following two have been most widely accepted:

1. Additional steel, in the form of "doubler-plate" or an increase in thickness of structural member in splash zone, is sacrificial in nature and the thickness is based on the theoretical maximum penetration rate in the splash zone — 20 mils per year is a com-
2. Monel (70 percent Ni, 30 percent Cu) sheathing is extremely resistant to corrosion by sea water. Its disadvantages are high cost (approximately $3 per sq ft for 16 gage Monel installed) and susceptibility to mechanical damage.

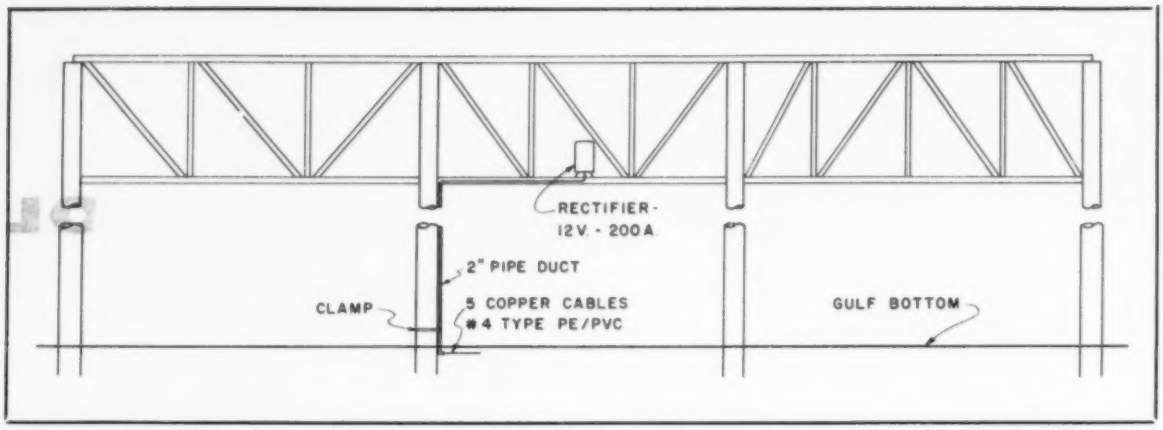


FIG. 1. **Rectifier and duct location** on the living quarter platform, and is a part of Project No. 4, now mostly complete.

monly accepted rate although 40 mils per year has been experienced. Its prime advantages are that, although susceptible to corrosive attack, its limitations are realized and designs can be made according to necessary requirements. Also, it is more economical than other protective measures. The disadvantage is the added weight to the structure. Other types of protection which have been experimentally used or proposed are wrought iron, glass lining, polyester jackets with a corrosion-inhibiting mastic in the annulus between piling and jacket, and epoxy resin — fiberglass armoring.

With due consideration to the problem and various methods of effecting protection in the splash zone, Freeport decided to protect this region by installing a section of rolled steel 0.875-in. thick in the permanent structures at −2 ft to +15 ft mean Gulf level and 0.6875-in. thick in the temporary structures. The reason for the +15 ft upper limit of the splash zone was to allow for subsidence of the structure.

Permanent structures include the Y-tower back to the power plant and intermediate structures. The temporary structures are the production platform and the five towers leading to it. Since the pilings above the splash zone are 0.50-in. thick, the added steel in the splash zone of the permanent structures represents an addition of 0.375-in. and in the temporary structures 0.1875-in. The splash zone steel, like the superstructure, is coated with an inorganic zinc silicate.

Protection of Submerged Area

The method of corrosion control of the submerged section of the offshore platform will be cathodic protection.

Cathodic protection of steel in sea water is effected by causing current to flow through a circuit consisting of an anode and a cathode (the steel to be protected) with an external connection between them. The voltage generated to allow current flow can be one of two principal types:

1. Impressed by a source through an inert anode, such as graphite, this system is referred to as an impressed current cathodic protection system.
2. Galvanic in nature, the result of the natural difference in potential of various metals in an electrolyte. For example, in sea water magnesium is at a higher potential than steel. Therefore, if magnesium is externally coupled to steel, the magnesium (anode) will corrode as current flows from it through the sea water to the steel (cathode). The current is grounded through the external coupling, thereby completing the circuit. This type of cathodic protection system is a galvanic, or sacrificial system.

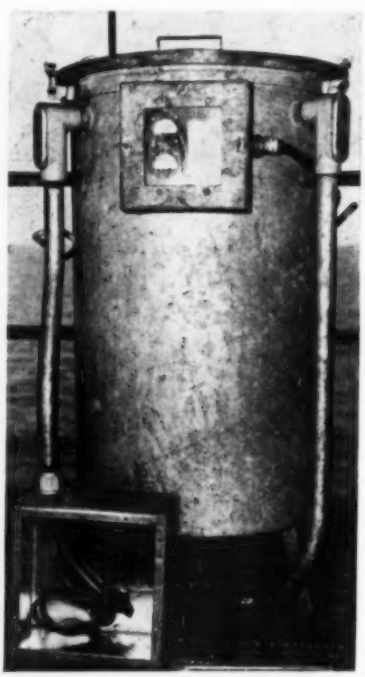


FIG. 2. **A 12-v, 200-amp rectifier** on the production platform. At lower right is a junction box that, when complete, will house 25 amp capacity rheostat to measure current output drop of each anode string. Each rheostat will feed to a buss, which in turn will tie into the large copper cable connected to the positive side of the rectifier. Enclosed in glassed section of the rectifier is "off-on" switch and voltmeter and ammeter showing rectifier voltage and current output.

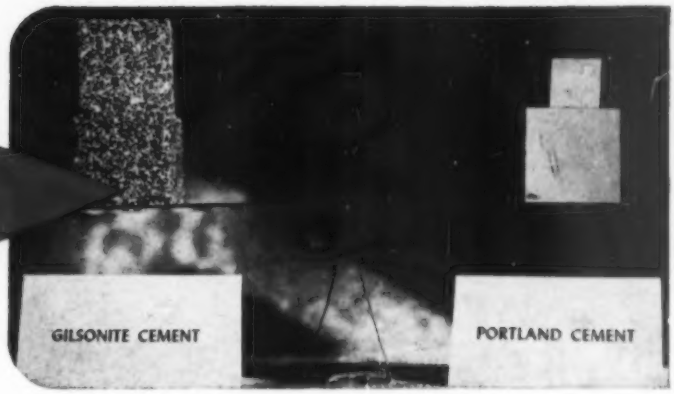
The current necessary to attain the protection of steel in sea water varies according to the velocity of water past the steel to be protected, variations of oxygen concentrations and temperatures, conductivity of electrolyte and impurities in the steel.

For stationary bare steel in sea water, the amount of current necessary for elimination of corrosion has been established by experience as 0.003 amp per sq ft. When the steel becomes "polarized" (equalized voltage throughout the steel which reduces the necessary voltage required for cathodic protection), current requirements will be lowered to approximately .0025 amp per sq ft.

Design of a cathodic protection system must begin with a knowledge of the actual steel area under water to be protected, which in turn will dictate the amount of current necessary to afford protection. Placement of the anodes to obtain even distribution of current is also important.

An impressed current system was decided upon in preference to a galvanic system because alternating current was readily available as a supply to rectifiers and the graphite anodes acting as a current source in an impressed current system can last for many years without replacement. The only maintenance required in an im-

GILSONITE CEMENT...



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In typical Halliburton tradition . . . another "first" has been introduced to the oil industry for better well cementing operations

Gilsonite Cement has been successfully field-proven for:

- high fill-up cementing
- multiple stage cementing
- plug back operations for lost circulation
- setting production liners in gas wells with weak formations

★ WHAT IS GILSONITE?

A new light weight additive (sp.gr. 1.07) that will produce a low density cement with slurry weights down to 10 lbs./gal.; adding volume, *NOT* weight to slurry. Gilsonite is unlike any other known material and is an excellent lost circulation additive for cement. It is milled and graded to correct particle size for this particular field use. It is generally used with portland cement, with or without Bentonite, Pozmix or Pozmix 140.

★ PROPERTIES OF GILSONITE...

- **Fluid required is very low due to graded particle size — each 50 lbs. needs but 2 gal. water.**
- **Non-cellular structure prevents loss from slurry — even under pressure.**
- **Economical — less Gilsonite Cement is normally required.**
- **High compressive strength — even at low temperatures.**
- **Lost circulation control is equal or superior — compared to other additives being used in most areas.**

• • • *get the facts about this new and unique cement additive for light weight slurries and lost circulation conditions . . . call your local or district Halliburton Representative.*

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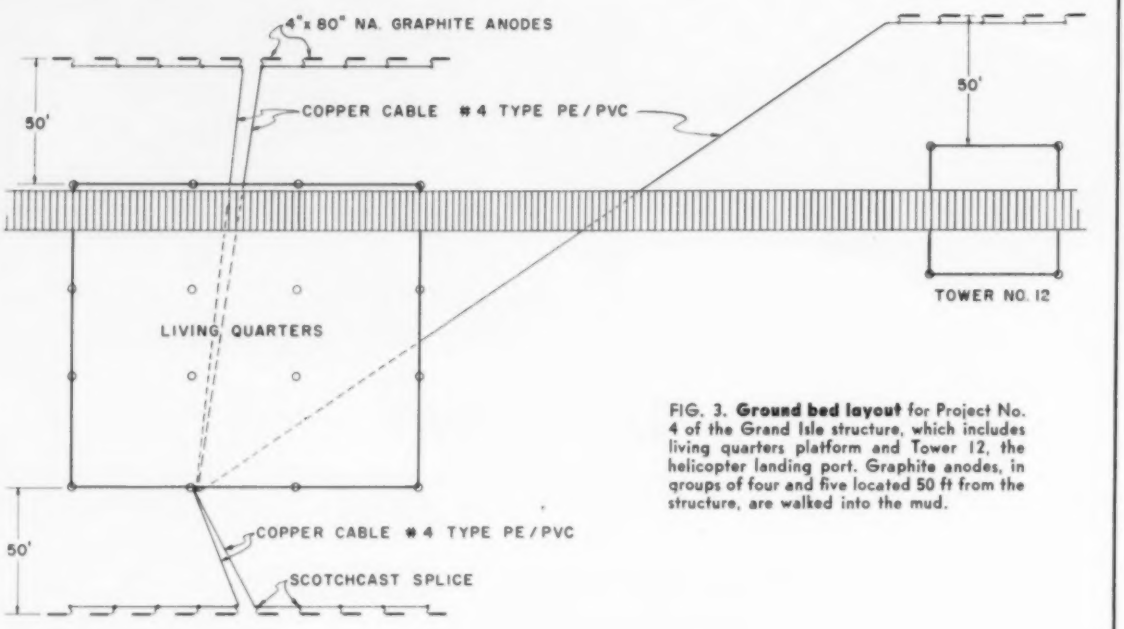

FIG. 3. **Ground bed layout** for Project No. 4 of the Grand Isle structure, which includes living quarters platform and Tower 12, the helicopter landing port. Graphite anodes, in groups of four and five located 50 ft from the structure, are walked into the mud.

pressed current system is in keeping the rectifier units in good working order and replacing any anodes which might become mechanically damaged.

Although galvanic cathodic protection is easier and cheaper initially to install, the system requires replacement of magnesium anodes at periods of two to three years.

Impressed Current System

Freeport's impressed current cathodic protection system was designed and is being installed by Corrosion Rectifying Company.

For installation purposes, the cathodic protection system was divided into five separate projects, as shown in Table 1.

Rectifiers are oil-immersed silicon stacks, 480 volts a-c input, three phase. The 8-v, 150-amp units are 24-in. diam by 40-in. high and weigh 625 lb. A-C power requirement is 1.4 kw maximum.

The 12-v, 200-amp units are 30-in. diam by 40-in. high and weigh 750 lb. A-C power requirement is 2.8 kw maximum.

The contractor designed the rectifiers to conform to the requirements of this job. The tubular units will have lower wind resistance, less weight, and will require less area for support than conventional rectangular rectifiers. The large number of small-capacity rectifiers allows for more flexibility of operation—one can be shut down for repair without greatly reducing the current output of the system.

Silicon stacks were chosen because of their high operating efficiency and good aging characteristics. The main disadvantage of silicon stacks, current overloading, is not anticipated.

The graphite anode system is based on a life expectancy of 10 to 15 years. Anode life is determined by the current discharge per square foot of anode surface, called current density. From Table 1, the anode current density can be determined by dividing the current requirement of each structure by the number and surface area (7.5 sq ft) of the anodes. It can be seen that this current density is approximately one ampere per square foot.

A primary consideration of design for the cathodic protection system was to make it as hurricane-proof as possible. With this in mind, the graphite anodes are "walked into" the mud, rather than laid on the bottom, to insure against severe wave action. The duct work from the rectifier down the piling, ending in a sweep (long radius curved pipe) 18-in. below the mud, also aids in making the anode ground bed system foolproof.

The anodes are in 4 and 5-anode groupings. Three or four groupings tie into each rectifier. The anodes are 50 ft from the structure.

By using a reference half cell (calomel and copper/copper sulfate are the principal half cells used because of their steady potentials, regardless of environment in which they are used), the

Table. 1. Cathodic Protection Project Description.

Project No.	Structure	Rectifier Quantity and Size	Anodes (4" dia. x 80" long NA graphite anodes)	Approximate Area to be Protected sq ft	Current Requirement (based on 3 MA/sq ft overall)
1	Tower #1 (Y-Tower)		8	16,790	50 amps
	Tower #2 (Rectifier location)	1 8v-150a	5	9,860	30 amps
	Tower #3		5	9,860	30 amps
2	Tower #4		5	9,860	30 amps
	Tower #5 (Rectifier location)	1 8v-150a	5	9,860	30 amps
	Tower #6		5	9,860	30 amps
3	Production Platform	3 8v-150a	66	145,460	436 amps
4	Tower #12 Heliport		5	9,860	30 amps
	Living Quarters (Rectifier location)	1 12v-200a	20	44,440	133 amps
5	Heating Plant (Rectifier location)	2 12v-200a	48	108,530	326 amps

potential between the structure and its electrolytic environment, sea water, can be measured. This potential is a measure of the degree of protection of the submerged section of the platform.

Superstructure Coating

The platform superstructure is protected from corrosion by inorganic zinc silicate coating. Selection of this material was based on results of its performance without any sign of failure for periods of up to seven years on various oil company structures in the Gulf, off the Texas Coast.

The inorganic zinc silicate consists of a reactive silicate liquid and a finely divided zinc powder that are mixed together before application. Before application, the surface must be blasted to "white metal" using an abrasive that will produce an anchor pattern of from one-half to one mil. This is necessary because the optimum thickness of the coating is two-and-one-half mils.

After air drying for one to two hours, the coating is cured by spray saturation with a solution which reacts to form a chemical bond between the coating and the steel in addition to the mechanical bond. The coating is ready for service 24 hours after application of the curing solution.

FIG. 4. **Graphite anodes and cable** used in the cathodic protection system. Anodes are 4-in. by 80-in. NA type; copper cable is No. 4 type PE/PVC.

Its physical properties are outstanding as it has excellent resistance to abrasion and impact, is unaffected after prolonged weathering in marine atmosphere, and is resistant to burn back during welding. This last property permits coating of individual members of the structure before fabrication, allowing sandblasting and coating operations to be carried out on the ground. It is not recommended for immersion or spillage of acid or alkali solutions, but it can be overcoated with vinyl or 100 percent epoxies in areas where this type of resistance is indicated.

Although application procedures may seem to be critical, if they are carried out properly an excellent atmospheric corrosion resistant coating will result. ★ ★ ★

1958 Geophysical Activity Down

Use of geophysics exploration methods in the world-wide search for oil and gas reserves was reduced in 1958 by 7.7 percent below the 1957 level. According to the annual report of the committee on geophysical activity of The Society of Exploration Geophysicists, Western Hemisphere activity decreased 14.2 percent. Eastern Hemisphere activity by all methods increased 9.7 percent.

For the first time seismograph explorations in the U. S. were reduced below 50 percent of the total for the world. Western Hemisphere work, however, accounted for 70.2 percent of the world's total seismic effort. The Eastern Hemisphere accounted for 29.8 percent of the world's seismic effort, 13.7 percent being carried out on the continent of Europe.

Gravity work throughout the world remained almost static, the SEG reports, registering only a 4.6 percent loss during 1958.

Sharpest decreases were noted in magnetic activity, with the U. S. reporting a 31.3 percent loss in activity, and the Eastern Hemisphere reporting a 53.8 loss.

In total Western Hemisphere work, significant gains reported in South America were more than offset by sizable reductions in the U. S. and Canada.

Several sizable shifts in activity were seen in 1958. South America, for example, accounted for 21.7 percent of the world's gravity work in 1958, compared to only 12.0 percent the previous year. As in 1957 the greatest concentration of gravity surveys in the Eastern Hemisphere was in Africa where 16.2 percent of the world's total gravity exploration work was done.

Most significant change shown in the SEG report was the phenomenal growth of methods other than seismic, gravity and magnetic. Although the amount is still small in relation to the total world-wide exploration activity picture, others (such as telluric current, electrical resistivity, radioactivity, electromagnetic and other types of electrical surveys) gained 262.7 percent.

By companies, geophysical contractors did 81 percent of the seismic work, 77 percent of the gravity work and the major portion of other geophysical surveys carried out in Europe in 1958.

Contract companies did 90 percent of the seismic work, 95 percent of the gravity work and 92 percent of all geophysical exploration work in Africa during 1958.

In the Middle East, geophysical contractors did 94 percent of the seismic work and all other work conducted in this region last year.

In the Far East, crews of contracting geophysical companies did only 55 percent of the seismic work and 58 percent of the gravity work.

Contract companies operated 61 percent of the seismic crews, 54 percent of the gravity crews and performed all airborne surveys in South America during 1958. In Central America, contractors conducted 94 percent of the gravity exploration and all other geophysical work.

During 1958, contract companies did 70 percent of the seismic work, 95 percent of the gravity work and all aeromagnetic work reported in Canada. In the U. S., contract companies did 53.5 percent of the seismic work, 50.3 percent of the gravity work, 34 percent of the ground magnetic work and all airborne magnetic surveys conducted during the year.

Cleaning Asbestos-Cement Pipelines

in Salt Water Disposal Service, East Texas

Unique tools, techniques speed never-ending line maintenance in 380-mile salt water gathering system

W. S. Morris
Vice President and General Manager
East Texas Salt Water Disposal Company
Kilgore, Texas

IT IS ESTIMATED that since the East Texas oil field was discovered late in 1930, that over 3,130,000,000 bbl of salt water have been produced along with the oil produced from the Woodbine sand. Salt water has been returned to the Woodbine sand in the field since June 1938 when Sun Oil Company put into operation a salt-water disposal system on its Pace lease in the southern part of the field.

The East Texas Salt Water Disposal Company was organized in 1942 and began a field-wide program of collecting salt water from the various oil-producing leases in the field, and returning it to the lower portion of the Woodbine sand, late in the same year. Up to January 1, 1959, 2,514,837,278 bbl of water had been returned to the reservoir. The salt water company had injected 1,874,455,059 bbl of the total which is approximately 75 percent.

The general story on salt-water disposal in the East Texas oil field has appeared in the trade literature.[1] However, some of the special problems such as the cleaning of asbestos-cement pipelines used in salt water disposal work have not been so well publicized. It is the purpose of this article to discuss some of the details in connection with the maintenance of over 380 miles of asbestos-cement pipelines used for the surface collection of salt water from the various leases in the field.

Composition of Salt Water

Salt water in the East Texas oil field contains several compounds that result in a deposit of a scale, and, if this scale should be deposited in the well, the pores in the sand would become clogged, reducing the effectiveness of injection. The scale which reaches the treating plants is precipitated by chemical treatment; however, in most instances the raw salt water from the gunbarrel or treater of the oil operator is not treated for scale prevention. As a result there is much deposition of scale in the pipelines between the various oil producing leases and the treating plants of the salt water company. Chemical composition of the salt water in the East Texas oil field is shown in Table 1.

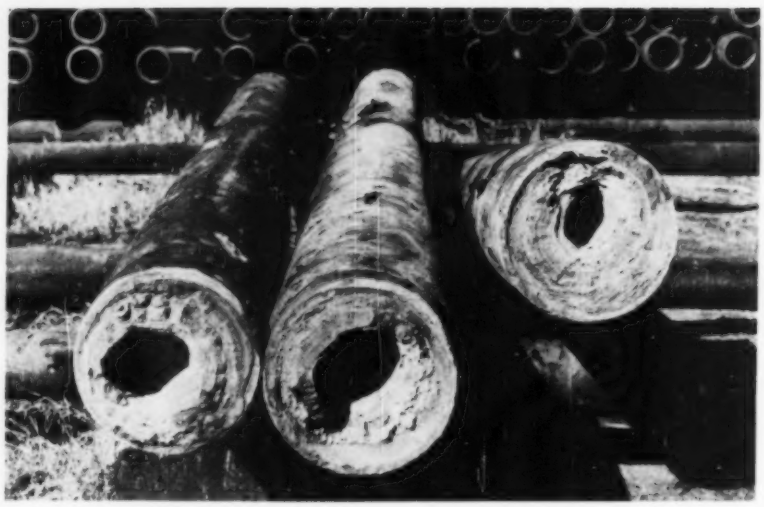

FIG. 1. **Calcium bicarbonate** scale deposition in asbestos-cement pipe in the East Texas salt water disposal system, such as this, prompt frequent and thorough cleaning methods. These sections of 8-in. line contain scale deposits formed over a period of years and has reduced the diameter to about 2-in., although the line was in constant use under a low pressure.

Table 1. Chemical Composition of the Salt Water in the East Texas Oil Field.

Component	Parts Per Million	Reaction Values
Calcium	1,176	58.7
Magnesium	197	16.2
Sodium	22,050	958.8
Carbonates	0	0
Chlorides	36,400	1,026.6
Bicarbonates	366	6.0
Sulfates	384	8.0

This analysis, by Plummer,[2] indicates that the water is high in sodium and chlorides, and contains enough calcium bicarbonates to be scale forming. The elements that cause trouble are the ones which, when oxidized by air, form insoluble precipitates. Very little iron (in solution) is contained in the salt water, while in the reservoir, but the concentration is increased after the water has passed through the operator's steel tubing, flowlines, and separators. Certain micro-organisms are found in the salt water after it is produced, and are known to play an important role in the formation of the insoluble precipitates.[3,4]

When the salt water enters the gathering system, it contains some oil in the form of microscopic spherical droplets and larger particles intimately mixed with the water. The "open type" system is used in the East Texas field and as a result, oxygen is allowed to mix with the salt water containing dissolved gases and compounds.

The temperature in the Woodbine sand of the East Texas reservoir is 143 F. As the water comes to the surface of the earth, the temperature is reduced but a temperature of 140 F is permitted to be used in the oil-water treaters so that a large part of the water which is delivered into the lines of the salt water company, is approximately 140 F. As the water travels down through the gathering lines, the temperature is lowered with the resultant precipitation of scale which deposits itself in layers in the gathering lines. Obviously any scale will reduce the capacity of the line to carry water. In

the design of a salt water gathering system a "C" factor of 120 is used. It has been found that accumulations which form in the pipeline may reduce the value of "C" as low as 100 or less. After the lines are cleaned, it may increase to as high as 130.

Asbestos-Cement Pipe

Asbestos-cement pipe is used almost exclusively in the pipeline gathering systems for salt water. The only places that steel pipe (usually cement lined) is used is in creek crossings or under highways and railroads. Many of the injection lines from the pumps to the disposal wells, are steel or cast iron, but the gathering system is composed of asbestos-cement pipe. This pipe does not deteriorate in salt water use and has been found most practical for this service.

Nevertheless, the asbestos-cement lines accumulate scale to such an extent that they have to be regularly cleaned to maintain capacity. The salt water company has at least four pipeline cleaning crews at work five days

FIG. 3. **Marshy terrain** that is sometimes found in laying the bolt-coupled salt water pipelines in the East Texas oil field makes it necessary to support the lines on trestles.

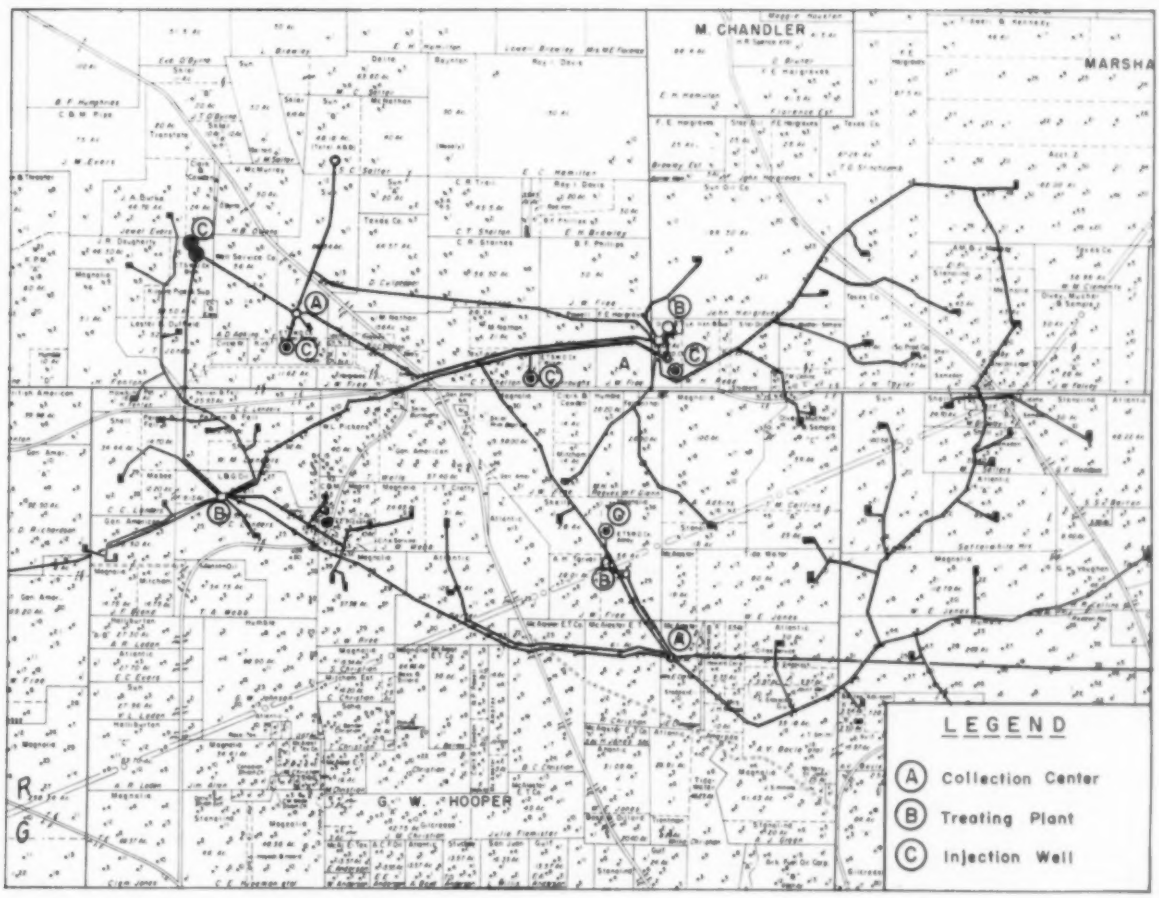

FIG. 2. **A portion** of the East Texas field shows part of the 380-mile asbestos-cement salt water disposal line system necessary to serve the area. Wherever possible gravity flow is used, although in several instances water is drained to a central point (collection centers) and pumped from those locations to the treating points.

FIG. 4. **Clean-out or scraper trap,** above junction point of two lines, may be cleaned without disruption of service in the other line. The trap is composed of two valves with a short section of pipe (spool) between. When the line is cleaned, the lower valve is pinched sufficiently to trap the scraper. Upon completion of cleaning operation, the valves are closed, the spool disassembled, the scraper removed; spool is then reassembled, the valves opened, and the line is again in operation.

a week cleaning pipelines exclusively. In areas where the scale deposition is not too severe, a pipeline scraper can be pumped through the line with good results. Even under these conditions the lines have to be frequently cleaned.

In other areas, particularly where high temperatures are used in treating the water-oil emulsion, the scale deposits in the lines are so hard that it cannot be removed by the usual methods.

Pipeline Scrapers

The scrapers that are used are of two types: First, a scraper consisting of a rubber-cementing plug with a ½-in. hole bored through the center and threaded on a ⅜-in. flexible cable followed by a wire brush, also strung on the cable. This assembly is pushed into the pipeline, and the pump pressure forces the rubber plug along the line. The rubber plug in turn pulls the circular wire brush behind it. This scrapes the sediment from the pipe walls and it is washed along the line. The second type of scraper is the conventional "go devil," "rabbit," or "pig," in common use by oil pipeline companies. This type scraper is not as flexible as the first type and is more likely to hang in tight places or turns, but may result in a better scraping job. A combination scraper, made by joining with a flexible cable the lead-end knives and cutter wheels of a conventional go-devil to a double cup rubber plug, is the most improved type of cleaning tool used by the company.

Pipeline Cleaning Machine

Where the scale deposits are hard and so firmly encrusted that they cannot be removed by the pipeline scrapers, they have to be removed by more strenuous methods consisting of a tool rotated inside the pipeline using a cutting edge or utilizing a "knocker." To accomplish this purpose a special pipeline cleaning machine was developed. The principles of the pipeline cleaning machine are not new in pipeline maintenance, but there are several unique features which make the machine particularly flexible and adaptable to our needs.

On the pipeline cleaning machine (Fig. 6), there are two gasoline engines mounted on a 4-wheel chassis: One is a 4-cylinder, 12-hp engine which is used to turn the rotating rods and cleaning tools in the pipeline; the other is a 1½-hp engine used to move the machine backward or forward at a slow rate through a reduction gear of 435 to 1 ratio.

The larger engine turns a rotating cutter or chain "knocker" which literally pounds the scale out of the pipe as the tool progresses through the line. Sucker rods are used to transmit the power from the engine to the tool. It has been found that ¾-in. rods are most satisfactory; lighter rods have a tendency to cork-screw or develop excessive whip. As much as 500 ft of line has been cleaned with this equipment without difficulty. Rotation speed is about 800 to 900 rpm. Several kinds of cutting tools have been used, each according to the need. Where the scale is hard and thick, a rock bit is used to bore out the material followed by a reamer. A chain "knocker" is effective where the opening in the pipe is large enough to permit its use.

The movement of the cutting tool through the pipe is carefully controlled

FIG. 5. **Typical wooden-tank collection center,** with a low-pattern red wood tank to insure maximum gravity fall, and with incoming gravity lines elevated to the top of the tank by A-frame supports, thus doing away with ells and tank flanges. This arrangment also permits pipeline cleaning tools to be pumped through the line to the tanks without difficulty. A centrifugal pump, with electric motor automatically controlled by a float switch, is utilized.

by the speed of the engine. With this degree of flexibility, the tools can be rotated at optimum speed for best cutting of the scale and the tool can be moved through the pipe at optimum rate. These two conditions can be controlled regardless of the thickness or hardness of the scale, because the two-engine drive makes each movement independent of the other.

The machine has successfully cleaned 4-in., 6-in., 8-in., and 10-in. asbestos-cement pipe in the field. As the operating crew becomes more adept in handling the equipment, the cleaning cost per foot of line can be reduced. The pipeline cleaning machine has been used for several months with comparative results as shown in Table 2.

New Machine

The first pipeline cleaning machine was so effective in cleaning lines that a second machine has been constructed with a slightly different arrangement of the engines. A small jeep with a 40-hp engine at 2000 rpm is used. A power take-off is connected to a hydraulic pump by a flexible joint. The pump delivers oil under pressure to a hydraulic motor, which in turn is connected by a chain and sprocket drive to the front end of the vehicle. In addition, a small independent engine is connected through a worm gear drive reduction unit in such a manner that the slow speed driving assembly permits the jeep (rear wheels) to be propelled from zero to 10 ft per min while the larger engine delivers the necessary power required to turn the cutting tool in the line connected with ⅞-in. sucker rods.

FIG. 6. **Pipeline cleaning machine** is a home-made unit designed and adapted for cleaning pipelines in the field. Cleaning tools are screwed onto the forward end of the sucker rods and are rotated inside the pipe. The machine also has power for forward and backward movement. Approximately 500 ft of line can be cleaned in one operation. The scale is pulverized and can be easily washed from the line.

FIG. 7. **Pipeline cleaning tools** are rotated at a sufficient speed so that the "knocker heads" literally chip the scale from the inside of the pipe. Tool on the left is used in 10 and 12-in. pipe — the circular bands keep the tool centered; the next three tools are used in 4, 6, and 8-in. pipe; and the tool on the extreme right is a conventional rock bit used when the pipeline is heavily encrusted.

The jeep is able to travel at highway speeds when going to and from cleaning jobs by disengaging the slow front wheel drive of the unit and delivering the jeep engine power to the rear wheels by means of a transfer case. This arrangement permits the vehicle to be an independent unit, moving from one location to the other without the necessity of being transported on a larger vehicle. The new machine which is more powerful than the first unit, has proved its ability to clean heavy scale from asbestos-cement lines in a most satisfactory manner.

The machines are in daily use in the East Texas field and the operation can be inspected at any time.

TABLE 2. Comparative Costs of Pipe Cleaning Methods.

Size Pipe Inches	*Amount Cleaned Feet*	*By Pipeline Cleaning Machine*		*Cost to Acidize*	*Cost to Replace*
		Total — $	*Per Foot — $*	*Per Foot — $*	*Per Foot — $*
4	5,652	429	0.076	0.292	1.23
6	14,008	745	0.053	0.585	1.76
8	362	116	0.320	1.298	2.33
10	471	177	0.376	1.798	2.93
Total	20,493	$1,467	$0.072	$0.545	1.65

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1. "Salt Water Disposal — East Texas Oil Field," by the Staff of the East Texas Salt Water Disposal Company. Issued by the Petroleum Extension Service, University of Texas, Austin, Texas, July 1958.
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3. Plummer, F. B., et al — "Effect of Certain Micro-Organisms on the Injection of Water into Sand." AIME *Petroleum Technology*, January 1944, TP1678.
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★ ★ ★

Answer To An Old Problem!

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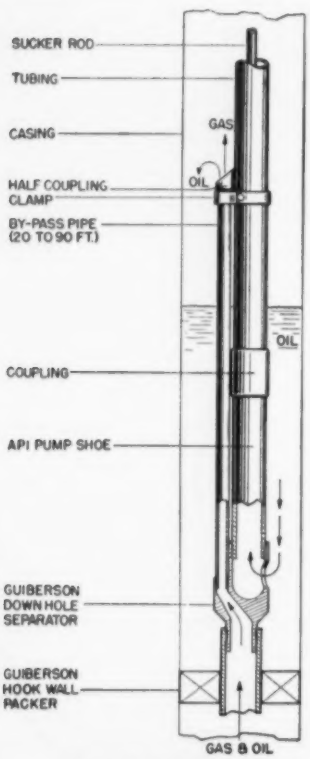
Down Hole Separator

The Guiberson down hole separator increases production and eliminates the problem of gas locks, etc., in pumping wells where the produced fluid has a high gas/oil ratio. Less than a foot in length, the separator is screwed directly into a Guiberson packer and the pump shoe fitted directly onto the separator. One to four joints of by-pass pipe, depending upon the producing characteristics of the well, are screwed into the separator and clamped to the tubing. Attached to the top of the by-pass pipe is a half-coupling cut on a diagonal which guides the unit past casing joints. By-pass pipe hugs the tubing as snugly as couplings permit. Production crosses over from the tubing below the packer into the annulus above it and is carried well above the pump shoe by the by-pass pipe. The large annulus above the packer allows the gas to break out of solution and the oil drops back to the large reservoir above the packer where it is picked up by the pump, comparatively free of gas. The separated gas is bled off of the casing continuously. Intake ports on the separator have a larger by-pass area than the tubing. The separator is precision machined from cast steel.



Schematic Installation

ENGINEERING DATA

Part Number	Minimum Casing O.D.	Tubing Size And By-Pass	Maximum Metal O.D.	Approximate Weight	Approximate Length
29439	4½"	2" x ½"	3¾"	12#	13¾"
29133	5"	2" x ½"	4⅛"	14#	10½"
28369	5½"	2" x ¾"	4½"	15#	10⅜"
28645	5½"	2" x 1"	4½"	15#	10⅜"
29606	5½"	2½" x ¾"	4½"	15#	16"
28370	7"	2½" x 1"	5⅝"	20#	11⅛"

Note: The 4½" x 2" and 5½" x 2½" sizes have NUE 10 round top and EUE 8 round bottom field connections; all other sizes are EUE 8 round both ends. When ordering specify part number, casing, tubing and by-pass size.

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On the next pages:
SPANG Extreme Line Tubing

Why SPANG Extreme Line Tubing is best for deep, high pressure wells

Name the tubing features you need for profitable completions in deep, high pressure wells—and you'll find that Spang Extreme Line Tubing has every one! Take make-up and running speed, for example. Wide, rugged, modified Acme threads provide fast joint make-up with minimum possibility of cross threading and maximum speed in running. Couplings are eliminated, and the integral type joint of Spang Extreme Line reduces threaded connections 50%.

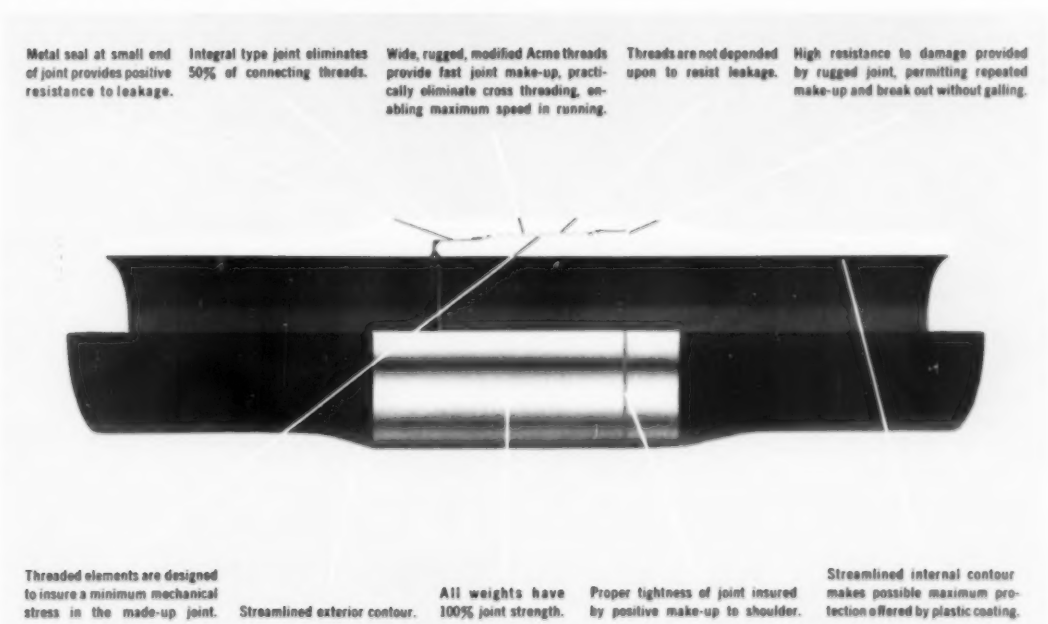
Need 100% leakage resistance? You get it with Spang. Male and female members make up into a sealed joint that is shoulder tight, and this unique seal resists leakage even under extreme conditions. The Spang Extreme Line joint is streamlined internally and externally with a minimum outside diameter.

Because of its streamlined exterior, Spang Extreme Line greatly minimizes the possibility of hanging up when running or stripping under pressure. The joint strength is 100% in all weights—its ruggedness permits repeated making up and breaking out without galling.

Spang Extreme Line Tubing is available in grades J-55, N-80, and P-105 to meet every well condition, and—if you anticipate paraffin accumulation or corrosion problems—you can order Spang's plastic coating to combat it (more about this on the next page). Spang Extreme Line Tubing is especially suited for deep, high pressure wells.

Next time you need tubing, be sure you get the best. Buy Spang Extreme Line Tubing or Spangseal Tubing.

Couplings are eliminated in this superior, 100% leak-resistant joint!


Metal seal at small end of joint provides positive resistance to leakage.
Integral type joint eliminates 50% of connecting threads.
Wide, rugged, modified Acme threads provide fast joint make-up, practically eliminate cross threading, enabling maximum speed in running.
Threads are not depended upon to resist leakage.
High resistance to damage provided by rugged joint, permitting repeated make-up and break out without galling.
Threaded elements are designed to insure a minimum mechanical stress in the made-up joint.
Streamlined exterior contour.
All weights have 100% joint strength.
Proper tightness of joint insured by positive make-up to shoulder.
Streamlined internal contour makes possible maximum protection offered by plastic coating.

On the next page: New SPANG Red Plastic Coating for Tubing!

◀ The joint design of Spang Extreme Line Tubing insures fast make-up, with minimum possibility of cross threading and maximum speed in running. Joint strength is 100% in all weights.

The new red plastic coating is approximately half as thick as the familiar green which has been used successfully for a number of years. National has the only mill facility of its kind for the unified control of tubular goods and plastic coating.

New Spang RED Plastic Coated Tubing available at lower cost!

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Like the thoroughly proven GREEN coating, the new RED coating is applied to a shot-blasted surface by alternate spraying and baking until the lining of predetermined thickness is obtained. The result is a hard, smooth lining which effectively resists paraffin deposition. (Field experience shows SPANG Plastic Coated Tubing eliminates 50% to 75% of the costly paraffin removal jobs required when uncoated tubing is used.)

We will continue to supply the GREEN coating. It costs more, but it's still the best investment for severe corrosive conditions. To give special protection to the joint sealing area in Spang Extreme Line Tubing, a Teflon corrosion barrier sealing ring is used. This ring completely closes the space between the end of the male member and the inner shoulder at the depth of the female member of the joint. The National Representative in your area can furnish full details.

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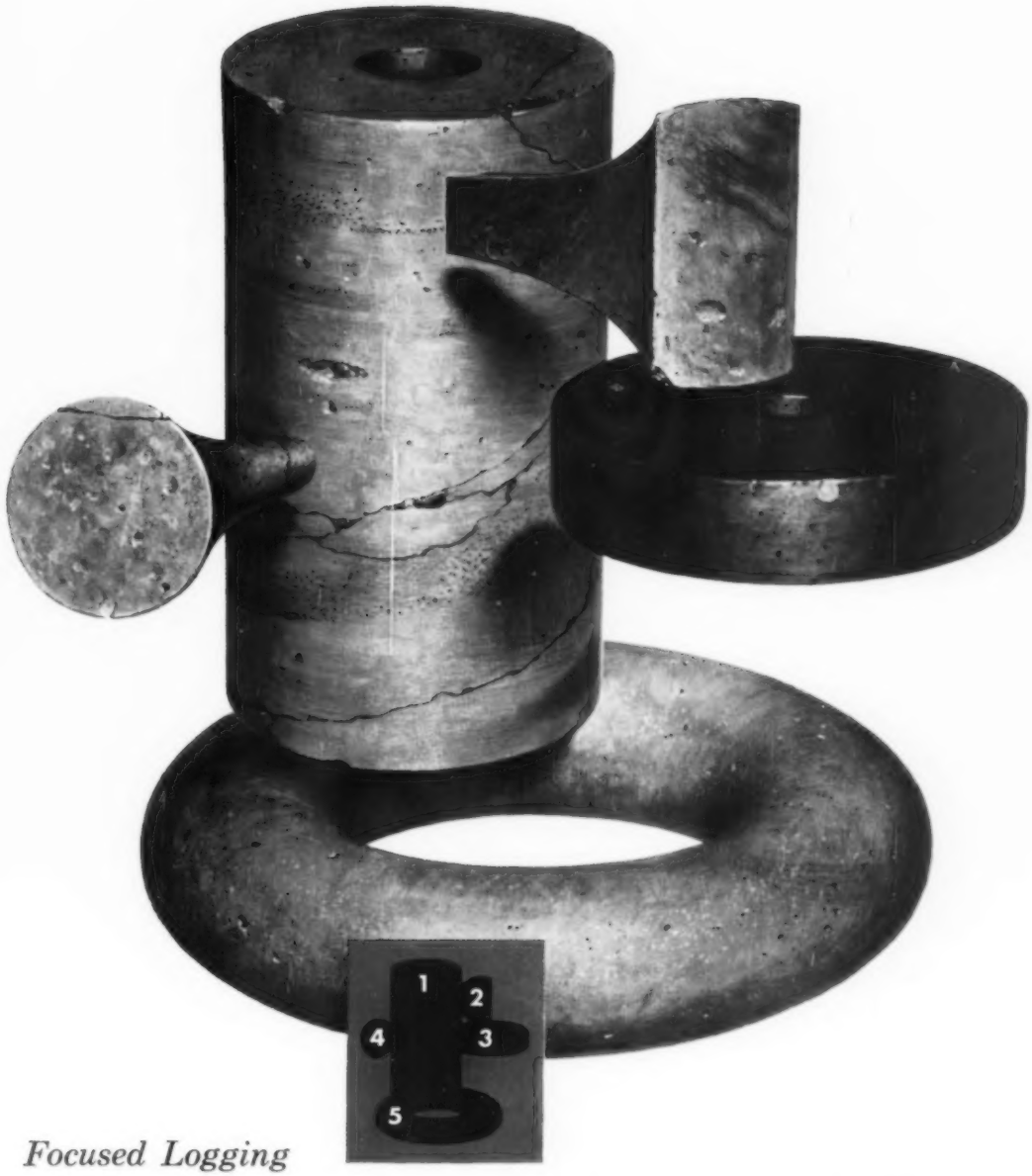

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The artist's concept of the patterns of Schlumberger Focused Logging is represented by sharply sculptured sections lifted from the formations surrounding the borehole. (1) Sonic Log (2) Proximity Log (3) Laterolog (4) Microlaterolog (5) Induction Log

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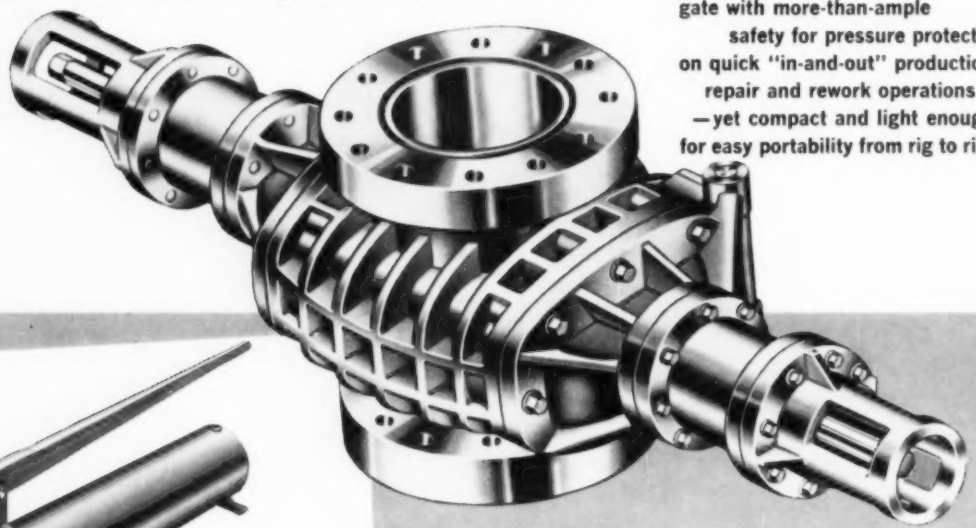

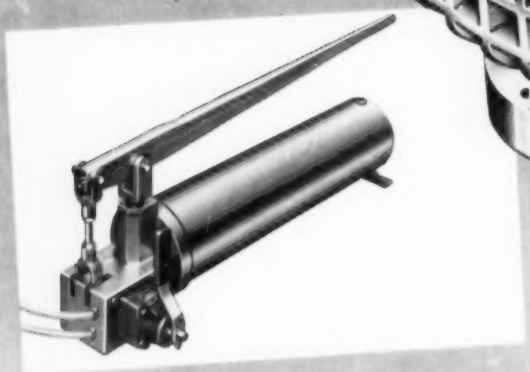

HAND PUMP OPERATION

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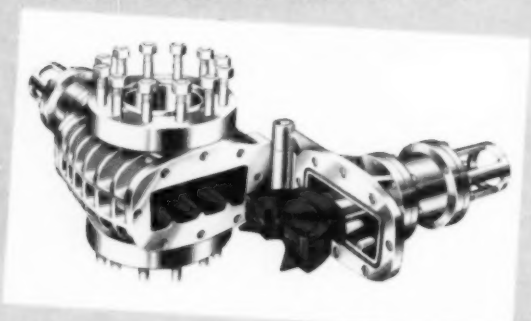

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59-102

New Chucks Improve Casing Coupling Screw-On

SPECIALLY-DESIGNED manufacturing equipment that gives greater assurance of trouble-free performance of high-strength oil well casing, is in production at the Aliquippa, Pennsylvania Works of Jones & Laughlin Steel Corporation.

The equipment eliminates stress-raising scars on the couplings, formerly caused by chuck grips on screw-on machines as the couplings were screwed onto the casing.

New screw-on chuck (right) eliminates stress-raising scars on couplings as caused by old-style chuck (left).

Gripping pressure on couplings is distributed by numerous striations over 15 times the surface area of the old single-edged grips. In addition, the gripping surfaces on the 8 to 10 shoes in each chuck are curved to the same radius as the coupling. Separate chucks are used for each size of coupling.

J&L engineers designed the new gripping elements in cooperation with the Taylor-Wilson Manufacturing Company as a component of this company's chuck. To assure uniform distribution of gripping pressure after the grips are tightened, the gripper shoes can turn slightly in lubricated cylindrical sockets as the grips are being tightened.

The gripping shoes were first used on couplings for buttress thread casing, grades N-80, P-110, and EHS-150. Coupling chucks of this new design are being made for tightening couplings on API casing.

Further assurance of maximum joint strength and proper seal on buttress thread casing is provided on the screw-on machine by a torque recorder-controller which maintains and records the predetermined torque applied in tightening every coupling on the casing.

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abrasion...
temperature...

This pump is especially efficient in wells with excessive float sand, dirty fluid, or high bottom-hole temperatures because the three concentric, free-fitting tubes use well fluid for the plunger seal. The plunger is also free-falling, which allows a faster pumping rate without being hard on the rods. H-F 3-Tube Pumps are fitted out to A. P. I. specifications, including standard balls and seats. Either regular or on-and-off types are available in 2" x 1¼", 2½" x 1¾", and 4"x3¼" sizes, and in 12' to 25' lengths. For hard-to-pump wells—or as a good, all-around pump for average wells—you can depend upon the H-F 3-Tube to make good production without frequent pulling jobs.

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EXPLORATION ACTIVITIES

MEXICO

Ed Pauley, Pemex Announce 'Important' Offshore Discovery

An important offshore discovery about a mile off the southwest shore of Mexico's state of Tabasco has been made and may be completed as a dual-producer, announces Edwin W. Pauley and Petroleo Mexicanos. Pauley, operating under an agreement with Pemex through Pauley Pan American Petroleum Company, said that "If the field follows the seismic pattern, it could be as large as one billion barrels of oil.

The discovery well, drilled to a TD of 10,000 ft, encountered several oil-productive zones in Miocene sand between 7000 ft and total depth. The first sand tested flowed at the rate of 1680 bbl of 38 deg oil per day through a restricted choke. A deeper sand has been tested, and a dual completion has been indicated. The well is located in a contract area, one of three which Pauley has, running about 250 miles across the Gulf of Campeche from Ciudad del Carmen in the east to just north of Veracruz in the West.

It has been indicated that Pauley will drill at least 100 wells in the area during the next two years, from drilling barges, stationary platforms and from directionally-drilled wells located onshore. Cost of the total project is estimated by Pauley at "more than $20,000,000," and indicated that public financing may be required.

AUSTRALIA

6500 Ft Test Planned On Moreton Anticline, Queensland

Phillips Petroleum Company and Sunray Mid-Continent Oil Company have jointly acquired interest in two concessions in the State of Queensland, Australia, embracing approximately 41,400,000 acres. One concession acquired from the Oklahoma-Australia Oil Company, is an Authority to Prospect covering 35,000 sq miles in the southwestern part of Queensland. This concession will be owned by Phillips and Sunray on a 50-50 basis and will be operated by Phillips.

Phillips and Sunray have also jointly acquired from Queensland American Oil Company an undivided one-half interest in a second Authority to Prospect in Eastern Queensland, covering approximately 29,500 sq miles. Under the terms covering acquisition of this concession, Queensland American agreed to drill a 6500 ft test well on the Moreton Anticline, approximately 30 miles south of Brisbane. Following completion of this well, Phillips and Sunray have the right to take over operations of this concession.

Oklahoma-Australia and Queensland American are wholly owned subsidiary companies of Lucky Strike Drilling Company, Tulsa, Oklahoma.

ALASKA

Mid-Summer Bidding Seen For 3,000,000 Acres in Tidelands

Leasing by competitive bidding has been proposed this summer for approximately 3,000,000 acres of Alaska tide and submerged lands. Tide and submerged lands will be offered in parcels up to 5760 acres. Leases will be awarded to the individual bidding the highest cash bonus.

Also, certain upland areas classified as competitive may be offered. Both will carry a rental rate of $1 per acre per year and a royalty rate of not less than 12½ percent. Upland leases in competitive areas are offered in parcels of not more than 640 acres. All noncompetitive lands carry a 2560-acre limitation. Under the new Alaska Land act, state-owned lands will be leased on a noncompetitive basis. Leases on these lands will be issued to the first qualified individual making application. Rental will be 50 cents per acre and a 12½ percent royalty.

KANSAS

Raymond Oil Completes Barton County Prospector

A new Arbuckle pool opener near Dundee, in the southwestern part of Barton County, is being completed by Raymond Oil Company. The well, No. 1 Unruh in Section 25-20s-15w, is about a mile southeast of the Unruh Pool.

On drillstem test the apparant discovery recovered 62 ft of gassy mud cut oil, 60 ft of free oil, 62 ft of gas-cut oil and 80 ft of frothy oil; tool was open one hour at a depth of 3630 - 40 ft. Bottomhole pressure measured 1170 psi. Casing was set at total depth of 3640 ft. Top of the Arbuckle was called at 3628 ft.

LOUISIANA

Gas-Condensate Find Indicated In East Cote Blanche Bay

Sunray Mid-Continent Oil Company and associates have made an apparent new field discovery at the wildcat No. 1 Louisiana State No. 3132 in the East Cote Blanche bay area of St. Mary Parish.

The well produced at the daily rate of 640,000 cu ft of gas and 268 bbl of condensate through a 10/64-in. choke following perforations at 15,040 - 54 ft opposite the Middle Miocene zone. Tubing pressure was 2400 psi. The oil gravity was 59.6 deg. Total depth is 15,241 ft.

The well, located on Lease 3132-16s-8e, is two miles out in the bay area. The new discovery was completed on a 1500-acre tract, owned jointly by Sunray and Skelly, and is about one mile south of the Glasscock Tideland gas condensate field.

TURKEY

Bolsa Chica Starts Third Test

Bolsa Chica Oil Corporation has commenced drilling operations on its third test well in the Republic of Turkey. This project, known as Hazro No. 2, is located approximately 3000 ft northeast of Hazro No. 1 which was recently abandoned at a total depth of 4050 ft, after negative drillstem tests of shallow oil sands penetrated at 1156 ft. Objective depth of Hazro No. 2 is 6000 ft.

MISSISSIPPI

Deep Jones County 'Cat Nears Smackover Objective

An oil show was detected in a drilling break at 14,012 - 16 ft and core between 14,016 - 50 ft in Sinclair Oil & Gas Company's deep wildcat, the No. 1 Masonite. The show was tentatively identified as basal Cotton Valley. Analysis of the sand in the core shows permeability ranging from 0.3 md, porosity from 10.2 to 14.7 percent, oil saturation from 10.7 to 18.3 percent, and water saturation of 30.5 to 38.8 percent.

The deep wildcat is three miles northwest of Pinview, Jones County, in the southeastern part of the state. The well spots in Section 15-9n-10w.

Additional deeper cores were taken but recovered all shale. Sinclair is drilling ahead to a Smackover objective, expected shortly. Operator was last reported coring ahead after running electric log at 14,080 ft.

Ask Me A Question

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Big questions deserve big answers. So, meet the latest addition to Core Lab's data processing center — IBM 650.

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Whether your well or field problem involves the use of basic or special core analyses, fluid analysis, secondary recovery investigation and planning, reserves study and evaluation, or pure research, Core Lab's 650 now contributes its sophisticated talents to the project.

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As an example, in many instances drill collars are lodged some distance from the bottom of the hole and when washed over they fall to the bottom, necessitating an extra trip into the hole to retrieve them. And, in many cases the collars lodge on the bottom requiring additional washover operations.

The Homco Drill Collar Spear is designed to prevent this. This tool has the spear attached to the wash pipe through shear pins allowing the spear to be screwed into the joint connection of the collar. After the connection is made the pins are easily sheared, allowing washover to begin. The spear is in the catch position as the collars are washed over preventing the collars from falling. A free point indicator may be operated through this tool at any time.

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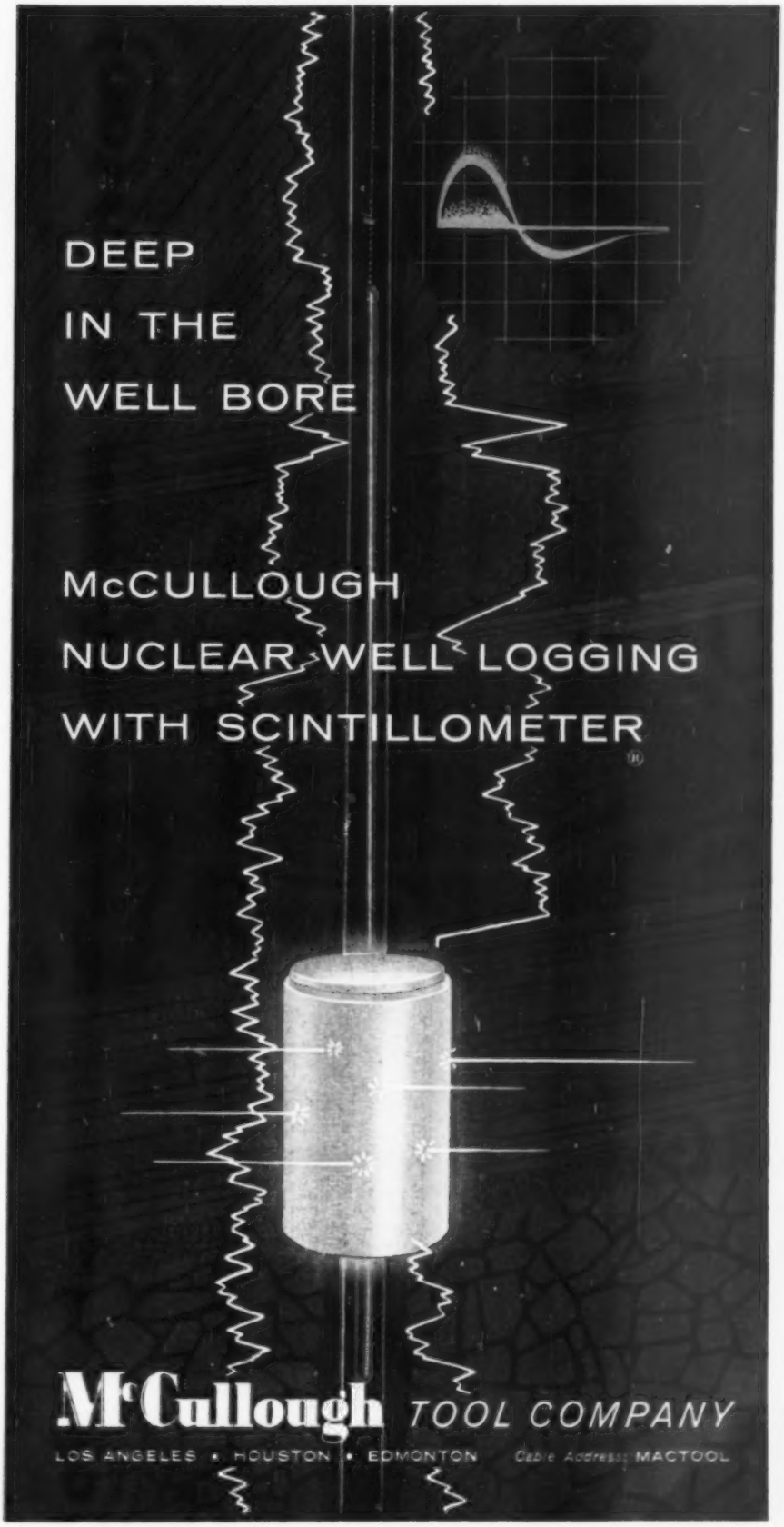
- ★ Porosity is determined with a higher degree of reliability.
- ★ Rugged, shock-proof design assures dependable operation.

Call McCullough on your next job – you'll get the best logs you ever had – and you'll benefit by more accumulated experience in nuclear logging with the scintillation crystal than all others combined.



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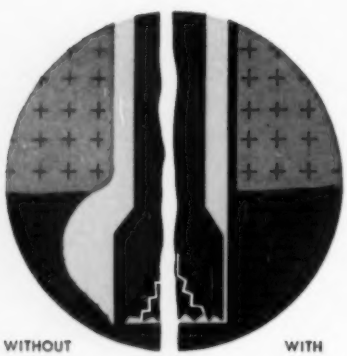
controls *mud filtration properties*



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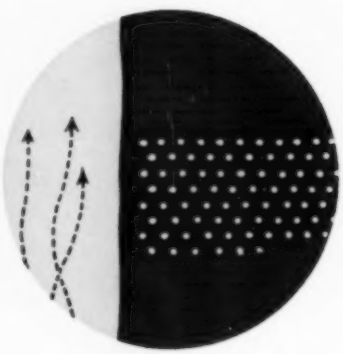

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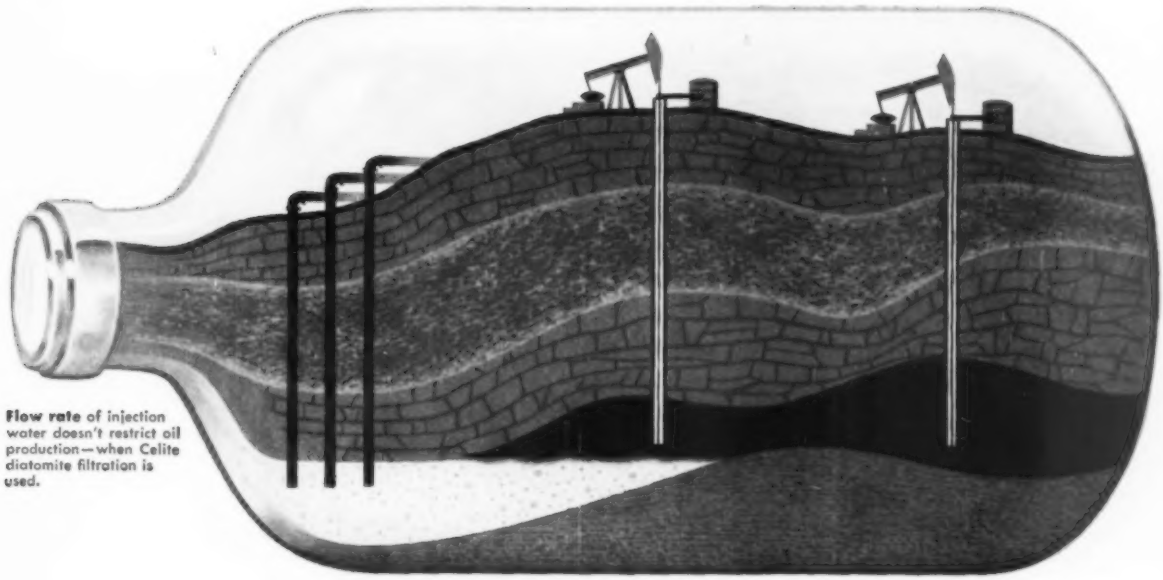

Flow rate of injection water doesn't restrict oil production—when Celite diatomite filtration is used.

No more *bottlenecks* in the formation pores!

Celite diatomite filtration removes all pore-clogging solids from injection water... permits fastest flow rates

NOW YOU CAN PREVENT the build-up of suspended solids that sharply reduces injection water flow and oil output. J-M Celite filter aids take *all* clogging corrosive solids out of the water before they can get into the well.

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Specially processed from the world's largest and purest commercially available deposit of diatomaceous silica, Celite is your best assurance of years of trouble-free filter operation. Nine standard grades have been developed to meet all filtration needs; you can pick the one that suits your system best. And when you reorder, you'll find that each grade of Celite remains constantly uniform.

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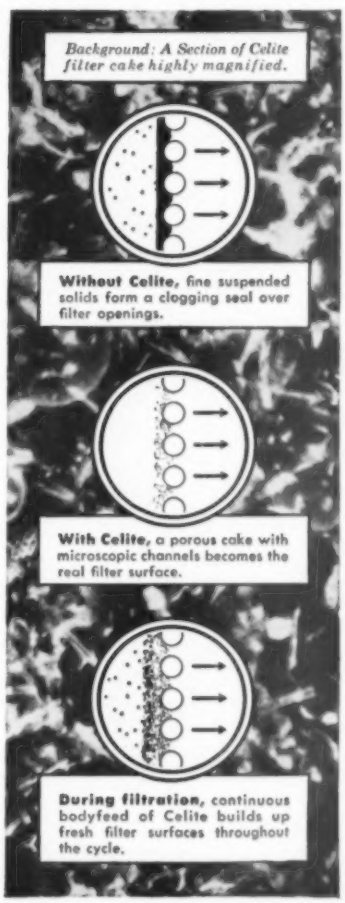
Background: A Section of Celite filter cake highly magnified.
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Jets go between cutters, hit directly on bottom.

Jet streams split, meet at cutter gage, then flow under the cutter (where chips are being cut) to the center.

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At any depth, the retarded set of Unaflo oil-well cement slurries sustain high initial fluidity. It allows proper placement and provides an added margin of safety for delays or emergencies.

Compatible with lightweight additives, Unaflo cement makes slurries of varying weight which pump easily and remain fluid under a range of bore and temperature conditions.

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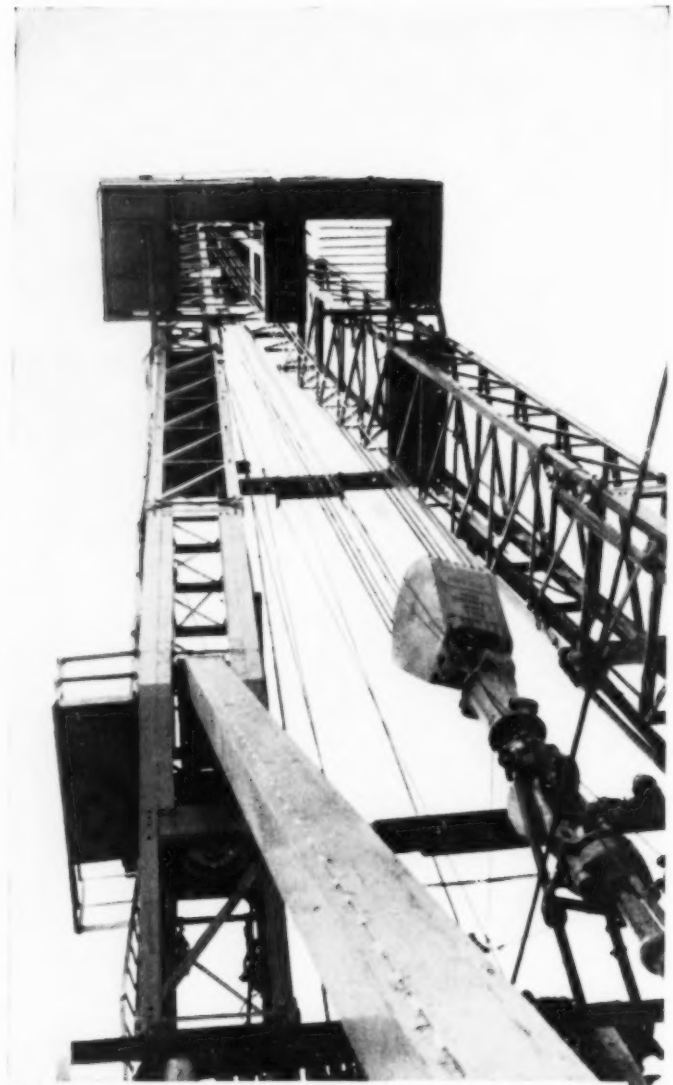

DRILLING DATA

Job: Cameron Parish, Louisiana—Tidewater Oil Company.

Drilling Contractor: Clegg and Hunt, Houston, Texas.

Job #1—5,016' of 13⅜" casing successfully cemented in 18½" hole with lt. wt. composition: 2,500 sacks Unaflo, 2,500 cu. ft. Stratacrete 6 plus 4% Gel by wt. of the cement. Slurry mixed at 12.5 lb./gal. Mud wt. 9.7 lb./gal. BHT 155° F. static.

Job #2 – 9⅝" casing was set in a 12¼" hole at 12,004'. Drilling mud in well had wt. of 13.6 lb./gal.; viscosity of 51; water loss 2.1 cc. Unaflo cement (520 sacks) used with Stratacrete 6 (520 cu. ft.) plus 4% Gel by wt. of cement for slurry wt. 13.5 lb./gal. on bottom. Schlumberger temp. 184° F. at 12,000' for est. static temp. 217° F.

Job #3—8½" hole drilled below 9⅝" casing; 4,131' 7" liner cemented at 15,996' with 625 sacks neat Unaflo cement. Mixing and pumping time, 1 hr. 15 min. Drilling mud wt. 16 lb./gal. Schlumberger temp. (at 15,500') 255° F.; est. static BHT 293° F.

Job #4 – Top of liner squeezed using 235 sacks neat Unaflo cement under max. pump pressure 2,200 psi; 15 sacks reversed out of well.

U-159

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It couldn't be done without the RUBBER SLEEVE Core Barrel

Complete core recovery, even in soft, unconsolidated or fractured formations

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Since that time, many formations that were formerly difficult or impossible to core, have been cored successfully with the rubber sleeve core barrel.

This rubber sleeve barrel actually encases the core in a protective rubber package, which reduces contamination to a minimum and eliminates many of the bridging, crumbling and jamming problems encountered with conventional barrels.

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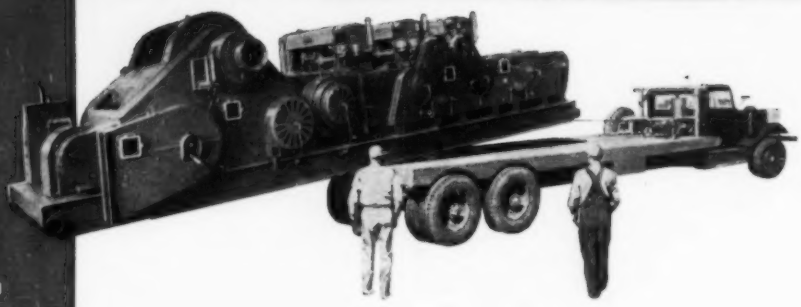
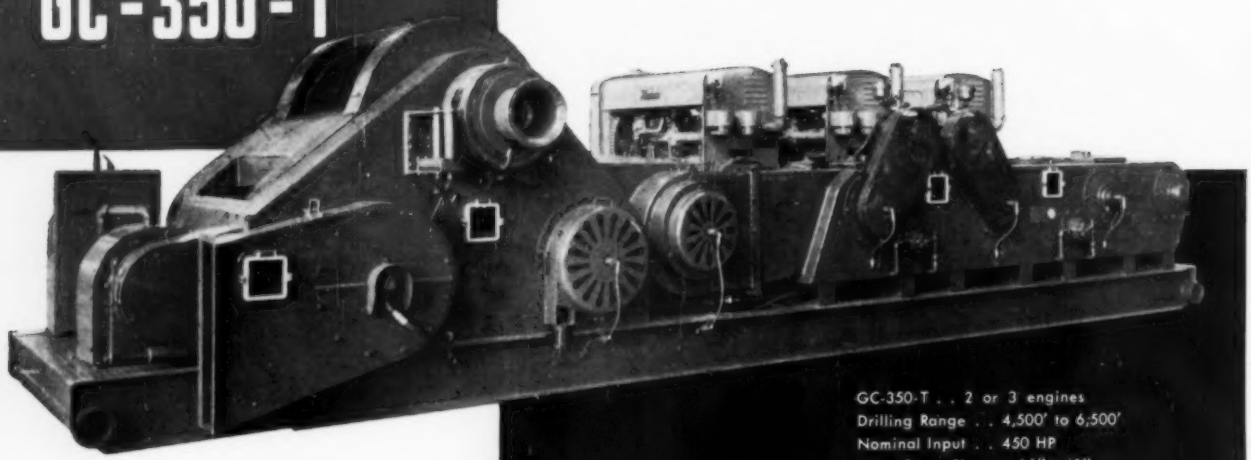


Rig is trucked and mounted on the substructure as a single unit.



GC-350-T . . 2 or 3 engines
Drilling Range . . 4,500' to 6,500'
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RUNNING TOUR with MEN in the INDUSTRY

William E. Fickert has joined the Ryder Scott Company Petroleum Engineers as a reservoir engineer. He was previously employed by Orchem Corporation. He has also worked for **Dr. Sylvain J. Pirson,** consultant. **Gordon T. West Jr.** has joined Ryder Scott as a petroleum engineer.

A. L. Linehan has been added to the geophysical staff of Republic Natural Gas Company. He was formerly with Geophysical Services, Inc.

Three new directors have been elected to the board of Prince Marine Drilling & Exploration Company. They are **Walter N. Maguire,** Maguire & Cole, Attorneys, Stamford, Conn.; **Walter L. Maguire,** investment adviser, also of Stamford; and **Stanley A. Wickstrom,** vice president, Associated Oil & Gas Co., Houston. 1959 officers selected by the new board include **D. K. Davis,** executive vice president; **S. A. Wickstrom,** vice president; **J. B. Griffin,** secretary and treasurer; and **Ralph Cochran,** assistant secretary-treasurer. Directors re-elected include Mosser; **David C. Bintliff,** Houston financier and oilman; **Jack G. Taylor,** David C. Bintliff Interests; **A. Knox Tyson,** president, Slick Oil Corp.; **H. V. Sherrill,** partner, Shields & Co., New York; and Davis.

Kenneth E. Montague has been named petroleum engineering counselor for Sun Oil Company's domestic production department. Montague will serve all of the company's domestic producing divisions in the U. S. and Canada from his headquarters in Beaumont, Texas. He formerly was supervisor of the reservoir study section in the operating department of Sun's Gulf Coast division.

Kermit E. Brown, assistant professor of petroleum engineering received the $1,200 Convair award from two Convair officials, **Robert H. Widmer** and **William Graham.** His nomination for the "excellent teacher" award came from engineering faculty members and students for excellence in engineering teaching.

George V. Myers, formerly vice president for production, was elected executive vice president of Standard Oil Company (Indiana). Meyers joined Standard of Indiana as general manager of production in 1956 to co-ordinate production and crude oil activities of the parent company and its principal affiliates. He was named a director in October 1956, and became vice president of production in 1958. He had been financial vice president and a director of Stanolind Oil and Gas Company (now Pan American Petroleum) before joining Standard of Indiana.

Hamilton P. Dendel has been appointed assistant to executive vice president **Robert C. Gunness.** He was formerly sales promotion and advertising manager of the company's central sales region.

Dr. Sylvain J. Pirson, University of Texas petroleum engineering professor and authority on reservoir engineering, has completed a survey of a new French oil field in the Paris Cretaceous basin. Dr. Pirson recently returned from France after spending a week there at the request of Petrorep, French exploration and producing company. He was asked to study the new field and advise French oilmen on the most efficient methods of completing the wells. **Charles Carlson,** Tulsa, Oklahoma consulting geologist, collaborated on the study.

Dorris Ballew

Dorris Ballew has been named chairman of the board of all Loffland Brothers Companies. Ballew formerly served as vice chairman of the board of Loffland Brothers Company and Loffland Brothers Company of Canada. He succeeds **Ken Davis Jr.,** who has been named president of Kendavis Industries, Inc., International. **Robert W. Wire,** president of Loffland since 1948, has been named vice chairman of the board of all Loffland Brothers Companies, and president

R. W. Wire

John Rundle

of Loffland Brothers Domestic Companies. **John O. Rundle,** previously vice president of operations, was appointed president of all Loffland Brothers foreign companies.

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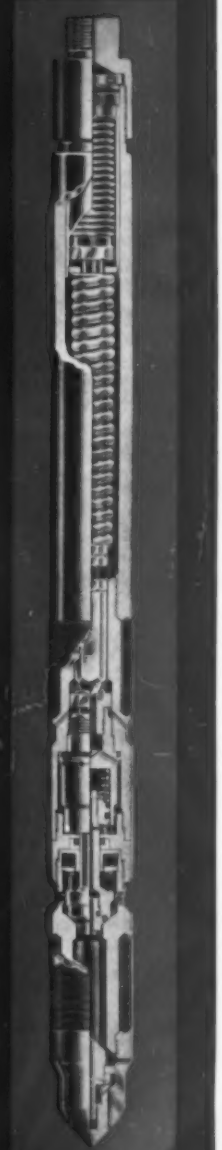
intermitting gas lift valve

- Wire line retrievable
- Full open unrestricted main valve port (½" dia.)
- Not affected by well temperatures
- Operates equally well with choke or intermitter surface control
- Field proven dependability



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Running Tour

Louis S. Wallace has been appointed chief geologist and geological engineer for the firm of T. D. Humphrey, Jr., Dallas. Wallace formerly was division geologist for the Mid-Continent division of Signal Oil and Gas Company at Ft. Worth.

L. S. Wallace

G. E. Hillhouse

Gordon E. Hillhouse, formerly district engineer for Sunray Mid-Continent Oil Co.'s South Texas district at Corpus Christi, has been appointed administrative assistant to **R. E. Foss,** senior vice president. **Everett L. Smith,** coordinator of training of the employee relations department, will be loaned to the production department to set up a training program and supervise training during its initial stages. **L. G. Rodgers** was named manager of engineering for production. Previously, he headed the department's gas division. **R. W. Griffith,** previously manager of unitization operations, was named manager of unitization and gas sales. Completing the production department's general office staff in Tulsa are **John Finch,** office manager, and **Alvin Summers,** personnel supervisor. **C. J. Kerwin, M. S. Patton Jr.** and **V. L. Smith** are new division managers to direct field operations out of three newly established production division offices at Oklahoma City, Houston and Midland.

W. T. Kennedy, Los Angeles division superintendent of production, will transfer to Tripoli, Libya as operations manager of the Oasis Oil Company of Libya, a wholly owned subsidiary of Ohio Oil Company. **R. C. Farley,** operations manager in Libya, will assume Kennedy's position in the domestic group. This is part of a rotation program to give domestic production officials foreign experience.

H. J. Gruy has been elected president of H. J. Gruy and Associates, Inc., with the recent incorporation of the consulting petroleum and geological engineering firm, and the company has moved into expanded quarters in the Southland Center in Dallas. Other officers elected were **Irene Haskett, C. M. Netherland** and **Arthur Wessely,** vice presidents; and **William K. Horn,** secretary-treasurer.

C. Arnold Brown has been added to the engineering staff of Keplinger and Wanenmacher, petroleum engineering and consulting firm, Tulsa. Prior to accepting the post, Brown had been chief petroleum engineer for Crawford Production Company.

Harold Longworthy has been named field representative in Venezuela for Tennessee-Venezuela, S. A., Union Petrolera Venezolana, C. A., and Monsanto Venezuela, Inc., which have joint oil and gas interests with offices in Maracaibo. He had been field representative, since 1954, in eastern Venezuela for International Petroleum Company, Ltd. Tennessee-Venezuela is operated by Tennessee Gas and Oil Co., a division of Tennessee Gas Transmission Co.; Union Petrolera Venezolana is a subsidiary of Union Oil and Gas Corp. of Louisiana; and, Monsanto Venezuela, Inc., is operated by Lion Oil Co., a division of Monsanto Chemical Co.

Dr. Bradford Willard, head of the department of geology at Lehigh University for the past 20 years, has retired. He was presented with a silver tray by **Dr. Harvey A. Neville,** provost and vice president of the university. The inscription reads "Bradford Willard, for loyal service to Lehigh University, 1939 - 1959.

T. A. Kibby has been named manager, Western Hemisphere exploratory operations, Gulf Oil Corporation. He is replacing **Augustin Pyre** who will join the Gulf Eastern organization in London who replaces **E. S. Bleecker** as manager of exploration upon the latter's retirement later this year.

Dan L. Gardner has joined Northern Natural Gas Producing Company as chief production engineer. He formerly was with Crescent Petroleum Corporation, Tulsa, Oklahoma.

Diversa, Inc., (formerly C. G. Glasscock-Tidelands Oil Company) has announced the appointment of **M. M. Conn,** vice president, as district manager for the Corpus Christi district. In his new capacity, Conn will be delegated to supervise the company's operations in the Texas Gulf Coast area, as well as its wholly-owned subsidiaries operating in this region.

Gene Deadman has been promoted to district geologist, and will be in charge of all geological work in the Corpus Christi area. He replaces **Ed Hughston,** who was transferred to the company's executive office in Dallas. **Lee Birdwell** has been named district petroleum engineer for the South Louisiana district, New Orleans.

Lloyd W. Morgan of Shreveport has been appointed purchasing agent by Barnwell Drilling Company, Inc. He assumes a portion of the duties formerly handled by vice president **Sam W. L. Backus,** who also has served as purchasing agent. Morgan was in the specialty sales business for himself for the past year as a manufacturers' agent, and spent 4 years in sales work with Alten Foundry and Machine Works and for 8 years was with McGriff Sales Company.

James E. Finley, exploration manager for Continental Oil Company's southwestern region, has been selected from American industry to receive a 1959-60 Slogan Fellowship at the Massachusetts Institute of Technology, Cambridge.

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▸ **R. K. Tracy,** production manager of the Gulf Coast division, has been named assistant manager of Humble Oil and Refining Company's production department. He succeeds **R. E. Bridges,** who retired June 1. **John S. Bell,** manager of Humble's California area operations, replaces Tracy. **Richard E. Faggioli,** area geologist in the California area, becomes acting manager there.

R. K. Tracy

J. S. Bell

▸ **Paul N. (Red) Adair** has announced formation of his own company to serve the oil industry, handling well control, oil well fires, blowouts, and consultations. "Red" Adair has earned a reputation as one of the world's best qualified oil well fire fighters during a period of more than 15 years in the business. The company will operate on a world-wide basis, around the clock whenever needed.

▸ **Thomas Herndon** has joined the geological department of Apache Oil Corporation, Tulsa. He formerly was director of geological projects for McCoy Associates and a staff geologist for Continental Oil Company.

▸ **Howard Warren** of the Houston oil firm of Ginther, Warren & Company has been elected to the presidency of the Petroleum Club of Houston. Selected to serve on the board of directors are **F. W. Bell,** manager, Petroleum and Chemical Division, Brown & Root, Inc.; **Joe T. Dickerson,** president, Shell Pipe Line Corporation; and **Raybourne Thompson** of the law firm of Vinson, Elkins, Weems & Searls. Schlumberger Well Surveying Corporation President **W. J. Gillingham** was elected a director to succeed R. R. McLachlen, deceased. Chosen to administer with Warren were **Walter Sterling,** independent oil operator, first vice president **E. Clyde McGraw,** president, Transcontinental Gas Pipe Line Corporation, second vice president; Thompson, secretary; **H. F. Beardmore,** Gulf Oil Corporation, treasurer; and Bell, assistant secretary-treasurer.

Board members in addition to those above are **H. M. Seydler,** vice president, Bank of the Southwest; **Michael V. Kelly,** vice president, Mound Company; and **R. R. Dean,** president, Bay Petroleum Corporation.

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NEW EQUIPMENT REFERENCE ANNUAL COMING JULY 15

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What's doing in DRILLING

Drilling Costs Studied In Special Report

A special study of drilling costs, the second ever compiled on an industry-wide basis, has been prepared by the American Petroleum Institute, the Independent Petroleum Association of America, and the Mid-Continent Oil & Gas Association. The study is based on 1955 and 1956 data — the most recent data available.

Some of the most significant highlights of the report are:

1. Oil men and oil companies invested $5,468,000,000 in drilling 113,056 wells in 1955 and 1956. Of this amount, $1,683,000,000 was spent in drilling 42,591 dry holes.

2. The average cost per well went up from $46,500 in 1955 to $50,200 in 1956, due largely to increased offshore activity, deeper drilling, and higher prices for labor and materials.

3. Drilling costs increased drastically as depths increased. Wells over 15,000 ft cost nearly 20 times more than those in relatively shallow areas of 2500 to 3750 ft.

4. Costs of offshore wells, in the Gulf of Mexico, averaged almost nine times more than those on dry land.

Copies of the report may be obtained from the offices of any of the three sponsoring organizations.

Offshore Drilling Platform Ends Voyage to Persian Gulf

The three-legged offshore platform "C. E. Thornton" has arrived on its first drilling location in the Persian Gulf, after a 11,500-mile voyage from the Gulf of Mexico. Reading & Bates, owner of the LeTourneau-type platform, report that the first hole will be in 100 ft of water, 25 miles from shore in the Neutral Zone of the Persian Gulf. The wildcat is expected to be carried to a depth of about 8000 ft.

The drilling venture represents combined efforts of the Tulsa firm and International Drilling Company. Reading & Bates will supply all equipment and some supervisory personnel, while IDC will manage the overall operation. Work is being done for Arabian Oil Company, a Japanese firm with headquarters in Tokyo.

AAODC Announces New Home Address

The American Association of Oilwell Drilling Contractors has announced the recent move of its headquarters office to Room 505, 211 North Ervay Building, Dallas 1, Texas. Offices in the newly completed building will retain the same telephone number, RIverside 2-2481.

Economics Does Not Control Russian Use of Turbodrill

Russian visitors to the United States recently shed a little light on the general use of the Turbodrill in the USSR. In discussions with members of the AAODC-API Study Committee on Turbodrilling, the Russians disclosed that they are more interested in speed than in the smallest possible cost per foot. Given a choice of smaller number of days on location for a greater cost per foot—often the case of turbodrilling versus rotary drilling—they do not hestitate to adopt the first solution, which is the opposite of what the Americans would do.

Russia is now in a state of fast expanding economy and the available rigs are taxed to capacity to fulfill the imposed quotas for increased footage drilled, increased crude production, and more reserves. This is the main explanation why more than 85 percent of the wells drilled in Russia are drilled with turbines.

— Shell Photograph

Spudding in... This unusual picture was taken beneath the derrick floor on a Shell Oil Company project just as the drill bit was lowered to make first contact with the earth. Only moments later, the drill pipe was rotated and drilling was under way. The workman is making a last-minute check to see that the bit is properly centered beneath the rig floor.

New Officers of Drilling Company Announced

J. Zeppa, president of Delta Drilling Company, has announced that the board of directors of the company has elected Harold J. Magner to the office of vice president of the company in charge of the northeastern division operations. Magner was formerly division manager with offices in Pittsburgh.

Also, the election of Eddie G. Durrett to the office of vice president in charge of the West Texas-New Mexico division operations, was announced. Durrett formerly held the position of manager of that division.

Rotary Rigs Operating in Oil Fields of United States and Canada

As reported to American Association of Oilwell Drilling Contractors by Hughes Tool Company.

	May 11	May 18	May 25	June 1
Alabama	7	7	7	7
Arkansas	12	10	17	16
Arizona	1	2	2	2
California—Land	94	92	93	98
California—Offshore	4	4	4	5
California, Total	98	96	97	103
Colorado	26	47	49	44
Florida—Land	2	2	2	2
Florida—Offshore	1	1	1	1
Florida, Total	3	3	3	3
Illinois	42	39	32	35
Indiana	10	9	6	4
Iowa	3	3	3	3
Kansas	146	130	141	132
Kentucky	9	9	7	6
North Louisiana	30	29	32	36
South Louisiana — Inland Waters	140	150	140	149
South Louisiana — Land	121	114	130	123
South Louisiana — Offshore	45	52	51	60
South Louisiana, Total	306	316	321	332
Maryland	0	0	0	0
Michigan	22	23	24	26
Mississippi	55	63	68	62
Missouri	0	1	1	1
Montana	22	20	19	16
Nebraska	26	20	20	29
Nevada	0	0	0	1
New Mexico	106	117	123	131
New York	1	1	1	1
North Dakota	40	39	41	31
Ohio	3	3	2	2
Oklahoma	247	234	259	239
Oregon	0	0	0	0
Pennsylvania	12	10	11	11
South Dakota	2	2	3	1
So. Tex & Gulf C. — Inland Waters	6	4	3	6
So. Tex & Gulf C. — Land	185	204	192	180
So. Tex & Gulf C. — Offshore	0	0	0	0
North & East Texas	176	153	160	158
West Central Texas	272	267	277	265
West Texas	155	157	163	164
Texas, Total	795	775	794	773
Utah	26	25	27	29
Washington	0	0	0	0
West Virginia	7	7	7	6
Wyoming	71	74	77	84
Total U. S.	2138	2116	2197	2166
Western Canada	121	124	141	148
Eastern Canada	0	0	0	0
Grand Total	2259	2240	2338	2314

Summit Drilling runs Wilson Slush Pump over 100 S.P.M. for a year and writes this letter!

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TOM COTTON
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May 4, 1959

Wilson Mfg. Co., Inc.
P.O. Box #1031
Wichita Falls, Texas

Dear Sir:

About one year ago we purchased one of your Wilson Giant Slush Pumps for use on our Rig #1. We thought that you might be interested to know that we are very pleased with its performance.

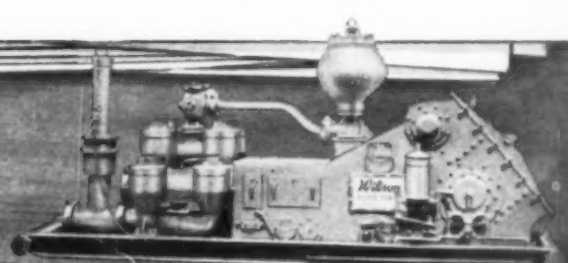
Although you rate this pump at 95 S.P.M. Max., we have been successful in running it at 100 S.P.M. and better. Even at these speeds we find that this Giant Pump runs smooth and quiet, with no fluid pound or surge.

At the present time we are drilling in the Bisti Field, near Farmington, New Mexico, and are using 6¼" liners to app. 3000' and then change to 5½" liners to total depth of app. 6000'. We run this pump normally at 100 S.P.M. and maintain 1050# to 1150# at our pump gauge.

Yours truly

Tom Cotton

Tom Cotton



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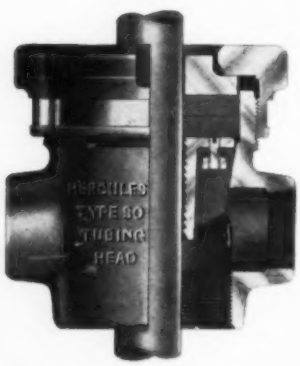
HERCULES TYPE SO

TUBING HEAD

Hercules "Type SO" tubing head is actually the lower section of the "Type SOS" tubing head, containing the slips and packing arrangement. It is particularly suitable for pumping due to its compactness, being approximately 12 inches high.



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CONTROLS RUST. RP-2 forms a barrier between metal and moisture. This blocks rust formation throughout the entire fuel system from gas tank to carburetor. Stops rust during storage at refinery and at service stations, too.

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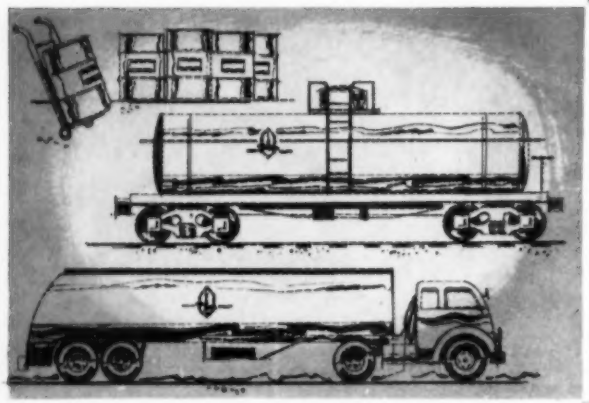

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147

PARTIAL ENTHALPY CHARTS . . . for Light Hydrocarbons

Presented here are charts for METHANE, ETHANE, PROPANE, *i*-BUTANE and *n*-BUTANE. It is believed that these data are the most reliable available at present

Dr. Arnold J. Gully
Mississippi State University, State College, Mississippi

THE NEED FOR ENTHALPY PREDICTION METHODS which are both accurate and convenient is well recognized by all who are engaged in process performance and design calculations. This combination is difficult to achieve in multi-component systems in which the enthalpy of a mixture depends upon pressure, temperature and composition. The accompanying charts are convenient for enthalpy prediction in light hydrocarbon systems at a pressure of 468 psia. Since small changes in pressure do not greatly affect enthalpy, these charts may be used for systems where the pressure differs appreciably from that value. Many deethanizers operate in this pressure range. The partial enthalpy data used was derived by Canjar and Edmister[4] from the Benedict, Webb and Rubin[1,2,3] equation of state. Since this equation has been found by many investigators to accurately predict PVT relationships, it appears theoretically that these values should be valid. It is believed that these data are the most reliable available at present.

No new data or correlating technique is presented. The value of the charts lies in the convenience of their use in process calculations.

In an early publication on partial enthalpies of hydrocarbons, Peters[6] presented charts which were not restricted to constant pressure and which included a composition parameter. He based his work on the assumptions that vapor enthalpy of a component above its critical temperature is independent of composition and that liquid partial enthalpy below the critical region is equal to the pure component value at the same temperature. Although this represented a significant improvement in enthalpy prediction, the later work of Canjar and Edmister[4] and Papadopoulos, Pigford and Friend[5] showed that the basic assumptions of Peters may be considerably in error.

Development of Curves

The datum state chosen for the enthalpy charts were the pure components in a hypothetical ideal gas state at 0 R. Ideal gas enthalpies at various temperatures were taken from the results of API Project 44[7]. Since component partial enthalpy is independent of pressure and composition in the ideal gas state, these data provide the temperature affects. Composition and pressure affects at constant temperature were determined from the data of Canjar and Edmister.[4] In certain areas which were not included in this article, values were taken from Papadopoulos, Pigford and Friend.[5] Both of these works are based on the Benedict, Webb and Rubin equation of state and are in general agreement. Cross plotting of the data was necessary to determine values at the desired pressure.

Isobutane Chart

Data on the effects of pressure and composition on the partial enthalpy of isobutane were not given in the source articles. In constructing the isobutane chart, pure component liquid and ideal gas enthalpies were taken as basis. Vapor deviations from ideal gas and liquid deviations from the saturated pure component were taken as the same as those of normal butane at equal reduced temperatures.

The relationship between the molar enthalpy, H, and the component partial enthalpies, H_i, is given by the equation

$$H = \Sigma X_i H_i \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where X_i is the mole fraction of a component in the mixture. In determining the enthalpy of a mixture of hydrocarbons at a given temperature, the molal average boiling point must first be calculated. This temperature is the sum of the normal boiling points of the components multiplied by their respective mole fractions in the mixture. Knowing the molal average boiling point, partial enthalpies of the components can be read directly from the charts. Example 1 illustrates the calculations involved.

Example 1. Calculate the enthalpy of a deethanizer reboiler liquid product containing 2.83 mole percent ethane, 37.25 percent propane, 16.66 percent isobutane and 43.26 percent n-butane at 453 psig and 222 F.

Component	X_i	T_{Bi},R	$X_i T_{Bi}$	H_i,Btu/lb mole	$X_i H_i$
C_2	0.0283	332	9.4	5750	163
C_3	0.3725	416	155.0	4850	1807
iC_4	0.1666	471	78.5	4900	816
nC_4	0.4326	491	212.4	4500	1947
			455.3R		4733

Molal average boiling point = −4.3 F.
H = 4733 Btu/lb mole mixture

How to Predict Octane Numbers of Multi-Component Blends

Ethyl Research Develops Equations for Calculation of Research and Motor Octane Numbers of Gasoline Blends

Accurate predictions of final blend octane numbers are necessary in any paper study of the refinery gasoline pool.

But linear calculation of final blend octane numbers generally is unsatisfactory. Volumetric average values will be higher or lower because of differences such as antiknock rating, hydrocarbon type, etc., in fuel components.

One common practice has been to introduce a blending factor to correct the final octane number. Generally, this works quite well once a given blending situation has been established.

However, none of the many techniques suggested for predicting blending deviation has proved to be so universally adaptable that it can be relied upon for broad application.

Predicting Blending Deviation by Equation. Ethyl Research has developed equations that are accurate for calculating both Research and Motor octane numbers. These equations may be applied in specific refining situations for both operating and economic calculations, or for wider, industry-type studies.

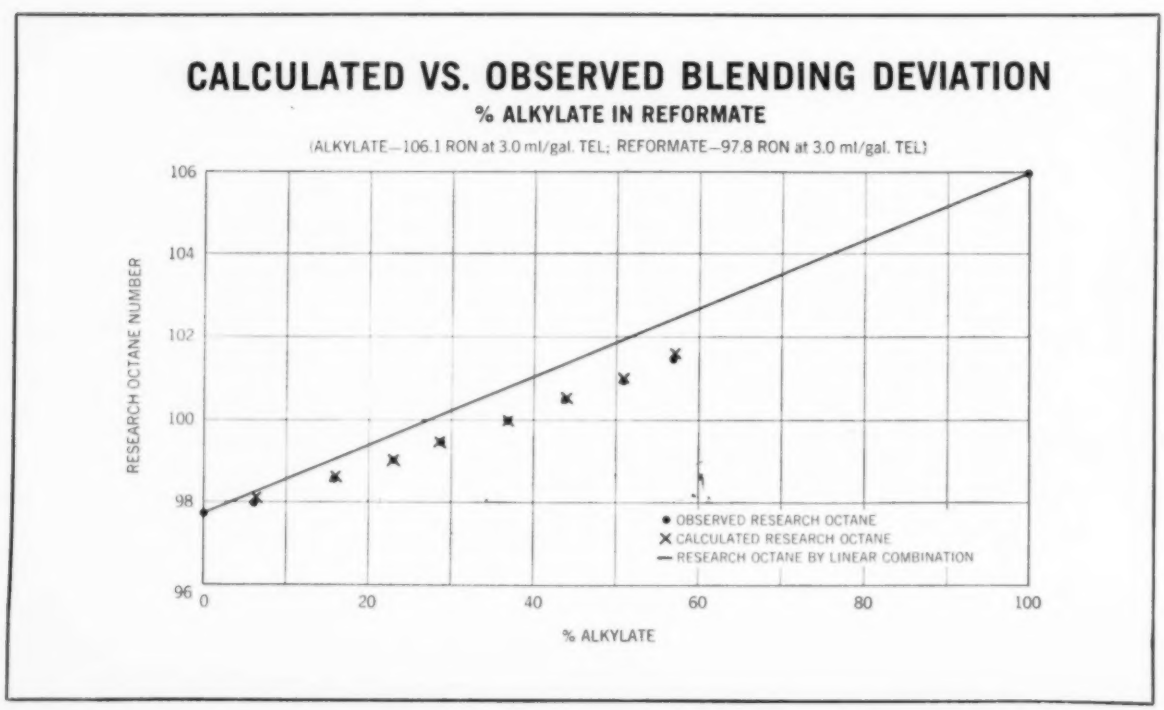
The equations fill the following requirements necessary to a good predicting technique:

They are accurate over a wide range of components and blends, since almost all possible types of gasoline components were included in the study.

They retain simplicity consistent with accuracy.

They are set up to handle different TEL levels.

While the equations were developed for use with high speed computers, they also are suitable for calculation with desk-type machines.



The Research Octane Number Equation

The equation for calculating Research octane is as follows:

$$R = \bar{r} + a_1\left[(\overline{rj}) - (\bar{r})\,(\bar{j})\right] + a_2\left[(\overline{0^2}) - (\bar{0})^2\right] + a_3\left[(\overline{A^2}) - (\bar{A})^2\right]$$

where:

R = Research octane number of the blend.
r = Research octane number of each component.
j = Sensitivity (Research octane number minus Motor octane number) of each component.
a = Equation coefficient.
$\bar{r}$ = Volumetric-average Research octane number.
$\bar{j}$ = Volumetric-average sensitivity.
$\overline{rj}$ = Volumetric-average of the product of r and j.
$\overline{0^2}$ = Volumetric-average of the square of the olefin content in volume percent.
$\bar{0}^2$ = Square of the volumetric-average olefin content in volume percent.
$\overline{A^2}$ = Volumetric-average of the square of the aromatic content in volume percent.
$\bar{A}^2$ = Square of the volumetric-average aromatic content in volume percent.

Equation coefficients have been established for use at tetraethyllead (TEL) concentrations of 3.0, 1.5 and 0.0 ml./gallon. Other TEL concentrations may be found by interpolation using TEL susceptibility charts.

A similar equation has been developed for calculating motor octane number.

Scope and Range of Development Data. Equations were developed by the method of least squares from 187 blends covering a wide range of finished gasolines. At each of three TEL levels, 135 blends out of 187 blends were selected for use in deriving and checking the blending equations. Fuels were from 24 refineries representing a good average of all U. S. facilities.

The number of components in the blends varied from 2 to 15. Component properties examined were Research octane number, Motor octane number, sensitivity, olefin content, aromatic content, sulfur content, gravity, and the 50 percent ASTM distillation temperatures.

TABLE 1 **Gasoline Components Represented in Blends Used to Develop Predicting Equations**

Alkylate	Aromatic Concentrate
Butane	Aromatic Raffinate
Catalytically Cracked Naphtha	C_5 and C_6 Isomers
Natural Gasoline	Pentane
Polymer	Reformate
Thermal Reformate	Thermally Cracked Naphtha

Several types of alkylate, reformate, catalytically cracked naphtha and other components were represented.

TABLE 2 **Range of Properties of Blend Components and Blends Used to Develop Predicting Equations**

Properties	Blend Component	Blend Range
Research Octane No.	59-113	85-105
Motor Octane No.	62-107	79-103
Olefin content, Vol %	0-100	0-60
Aromatic content, Vol %	0-96	0-70
Saturate content	0-100	25-86
Sulfur, Weight %	0-0.643	0.01-0.227

How Ethyl Research can help you

The accuracy of predictions can be improved by tailoring these equations to individual refining situations.

Ethyl Refinery Technologists are ready to work with you to establish equation coefficients from your blending data.

For an appointment with one of these specialists, see your Ethyl Representative.

Your Ethyl Representative also can supply you with a detailed engineering report of this study which served as a basis for the presentation, "A New Approach to Blending Octanes" at the New York meeting of the API, Division of Refining.

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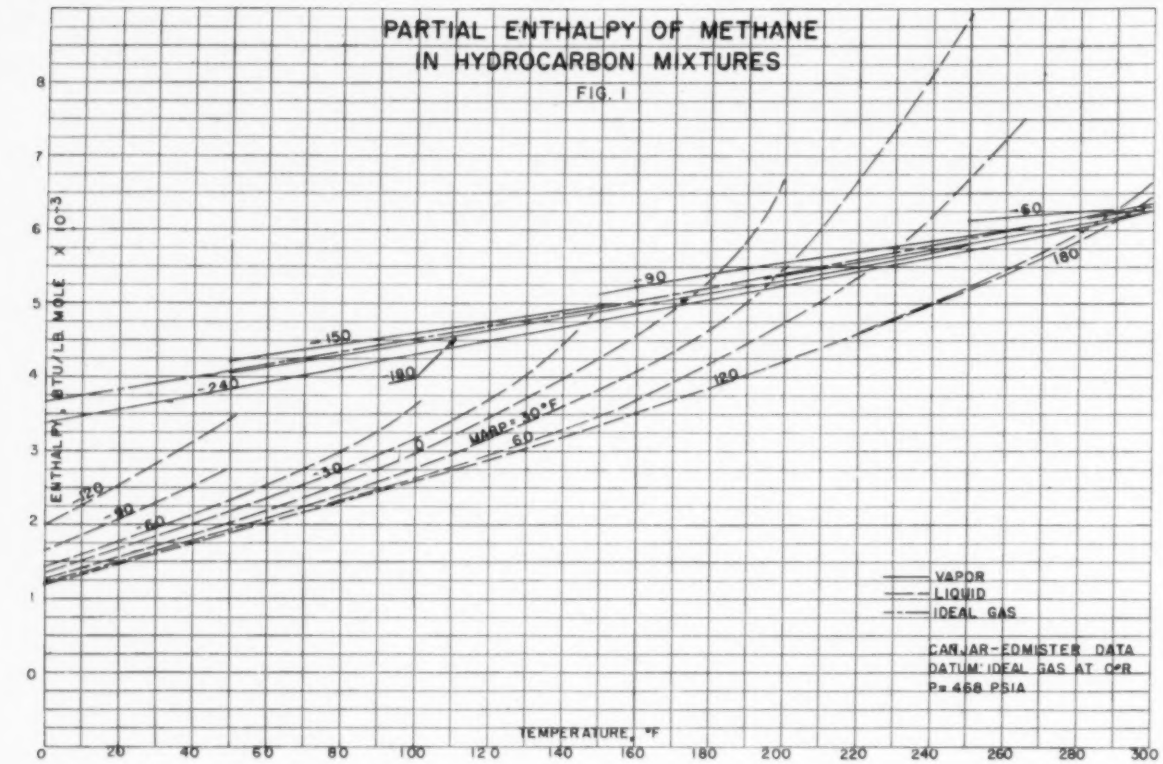
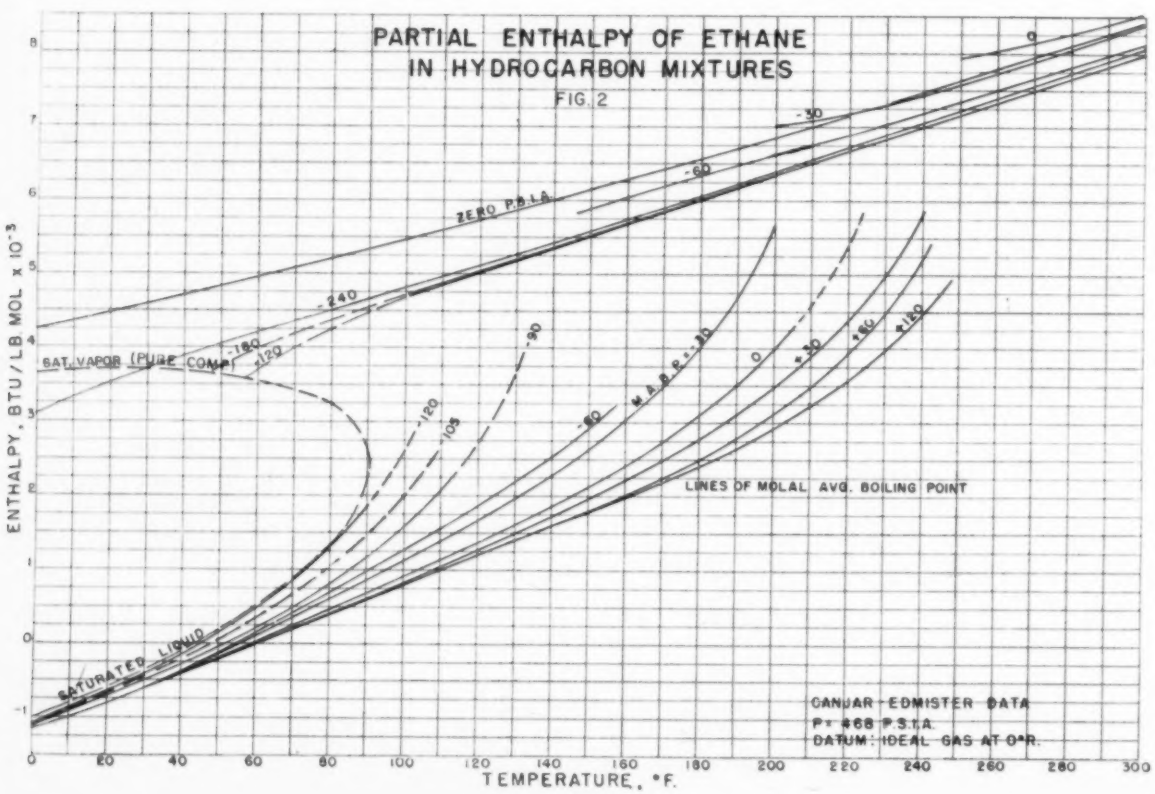
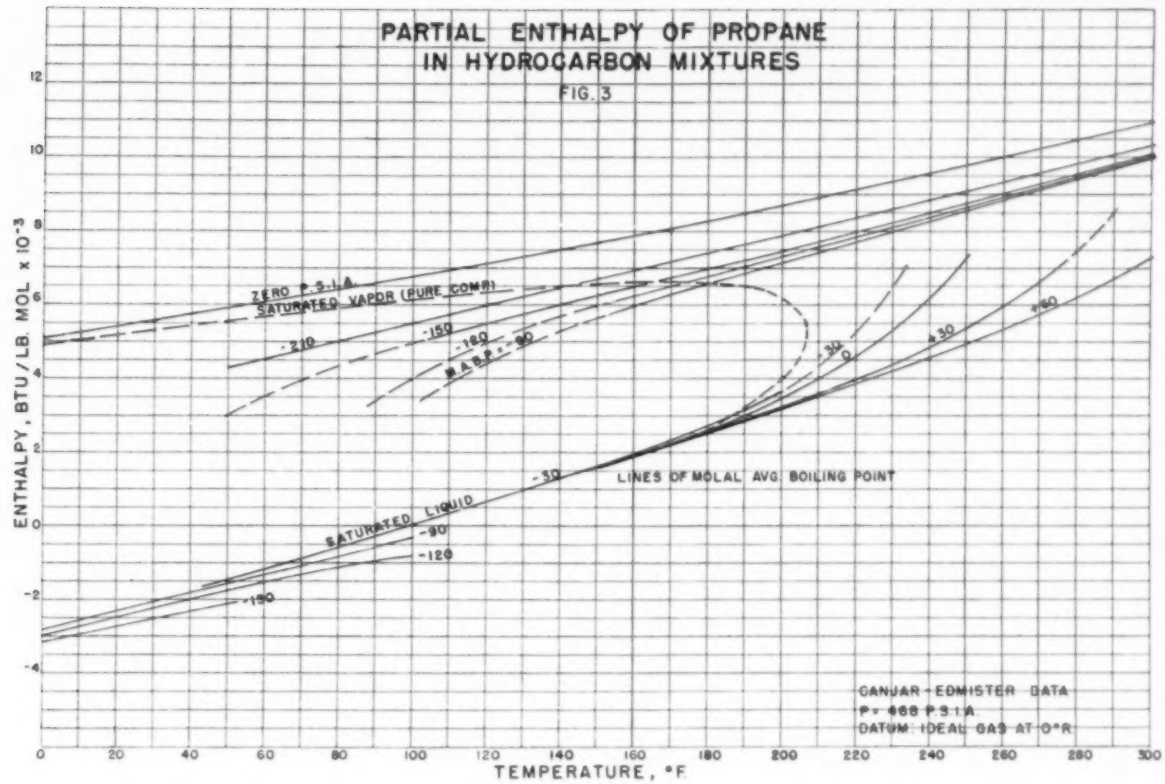
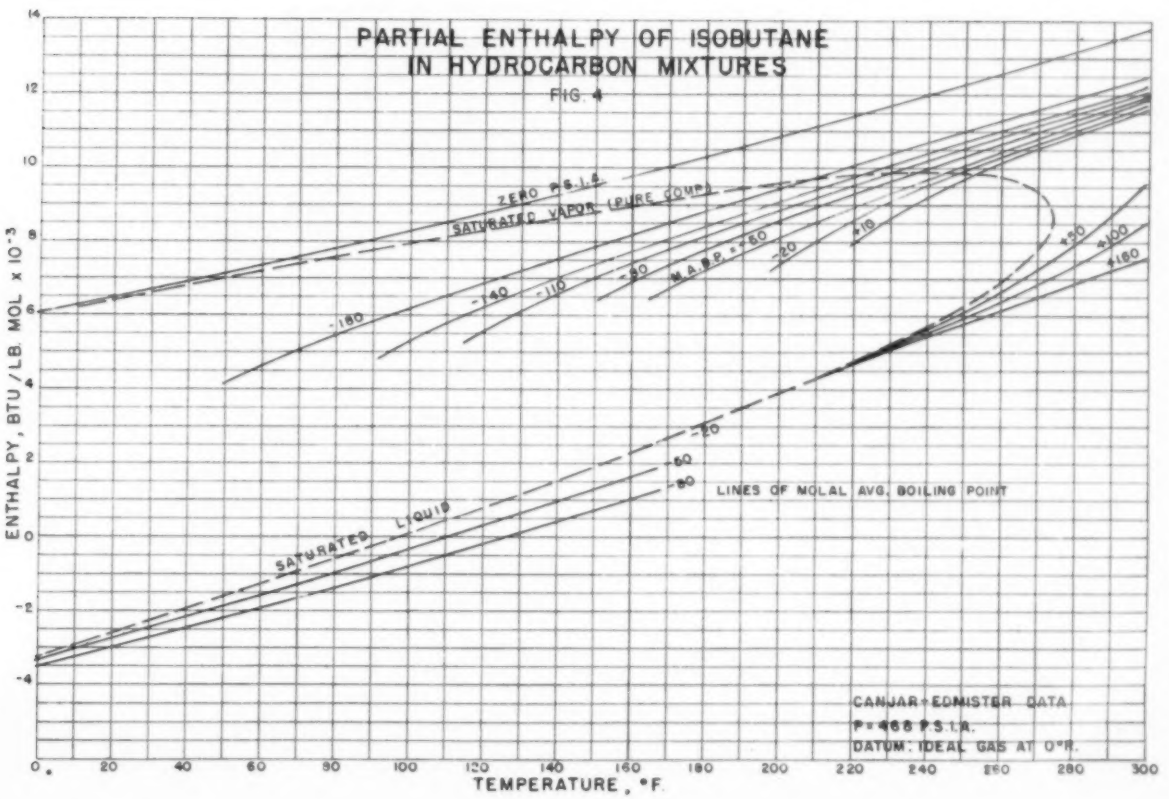
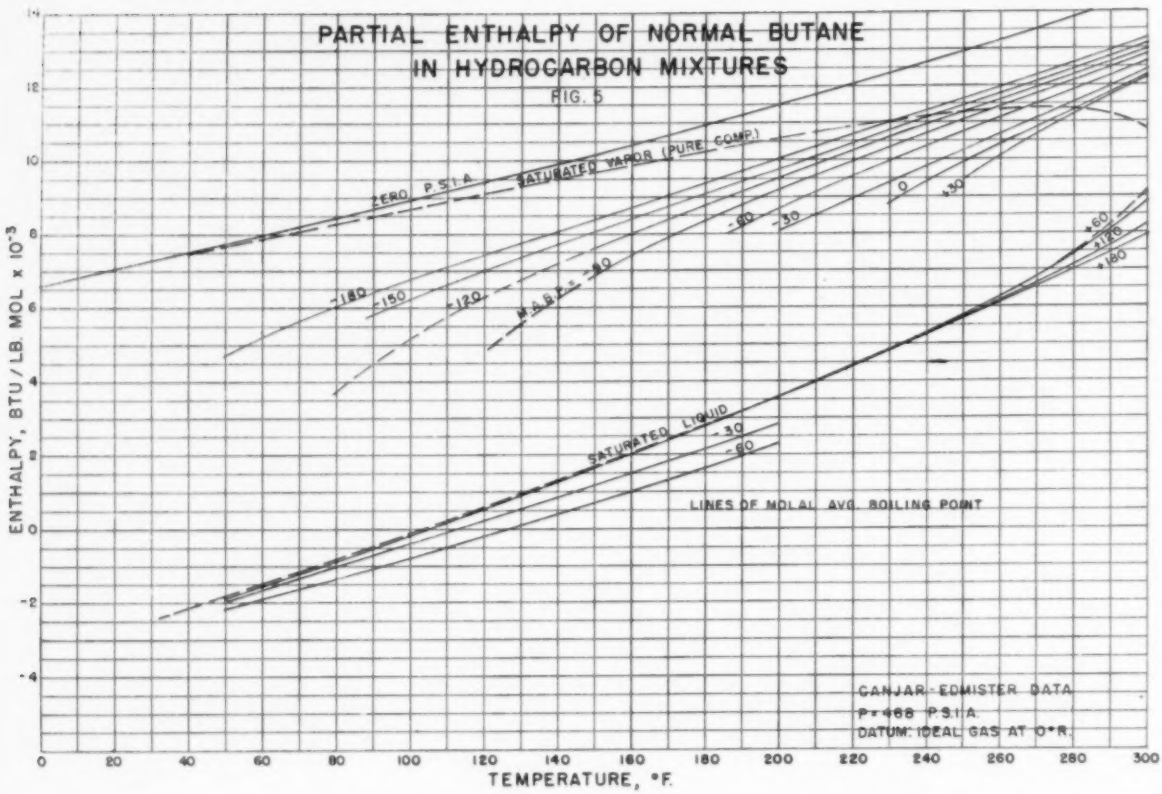

PARTIAL ENTHALPY OF METHANE
IN HYDROCARBON MIXTURES
FIG. 1
ENTHALPY, BTU/LB MOLE X 10⁻³
TEMPERATURE, °F
VAPOR
LIQUID
IDEAL GAS
CANJAR-EDMISTER DATA
DATUM: IDEAL GAS AT 0°R
P= 468 PSIA
MWAP = 30°F


PARTIAL ENTHALPY OF ETHANE
IN HYDROCARBON MIXTURES
FIG. 2
ENTHALPY, BTU/LB MOL x 10⁻³
TEMPERATURE, °F
ZERO P.S.I.A.
SAT. VAPOR (PURE COMP.)
SATURATED LIQUID
LINES OF MOLAL AVG. BOILING POINT
MWAP = 30
CANJAR-EDMISTER DATA
P= 468 P.S.I.A.
DATUM: IDEAL GAS AT 0°R.


PARTIAL ENTHALPY OF PROPANE
IN HYDROCARBON MIXTURES
FIG. 3
ENTHALPY, BTU/LB. MOL x 10⁻³
TEMPERATURE, °F
ZERO P.S.I.A.
SATURATED VAPOR (PURE COMP.)
-210
-150
-180
M.A.B.P. = -90
-30
0
+30
+90
LINES OF MOLAL AVG. BOILING POINT
SATURATED LIQUID
-90
-120
-150
CANJAR-EDMISTER DATA
P = 468 P.S.I.A.
DATUM: IDEAL GAS AT 0°R.


PARTIAL ENTHALPY OF ISOBUTANE
IN HYDROCARBON MIXTURES
FIG. 4
ENTHALPY, BTU/LB. MOL x 10⁻³
TEMPERATURE, °F
ZERO P.S.I.A.
SATURATED VAPOR (PURE COMP.)
-180
-140
-110
-80
M.A.B.P. = +60
-20
+10
+30
+100
+180
-20
-50
-80
LINES OF MOLAL AVG. BOILING POINT
SATURATED LIQUID
CANJAR-EDMISTER DATA
P = 468 P.S.I.A.
DATUM: IDEAL GAS AT 0°R.



$\bar{C}_{pl}$ and $\bar{H}_l$ — A Function of Temperature

Some fractionator computer programs that are currently in use require heat content data in the form of component liquid heat capacities and latent heats of vaporization as functions of temperature. These data must be determined from the partial enthalpies of the components. Since enthalpy is a function of composition as well as temperature, composition must be known as a function of temperature before the component enthalpies can be determined accurately. This information is usually not known at the outset of a problem. Therefore trial and error calculations are necessary to determine the temperature-enthalpy relationships. An initial assumption of product distribution will give an estimate of overhead and bottoms product compositions. Boiling point calculations will then give overhead and bottoms temperatures and the boiling point of the feed. These three temperature-composition points will permit calculation of liquid and vapor enthalpies at the three temperatures. Heat capacity and latent heats can then be estimated as first approximations.

The heat capacity of the liquid is usually represented by an equation of the form

$$\bar{C}_{pl} = a + bT \quad . \quad . \quad . \quad . \quad (2)$$

where $\bar{C}_{pl} = \left(\frac{\partial \bar{H}_l}{\partial T}\right)_p$, T is the temperature and a and b are constants. If heat capacity varies linearly with temperature as the equation requires, the mean heat capacity between two temperatures is equal to the heat capacity at the average

Dr. Arnold J. Gully

The author, Arnold J. Gully, a native Mississippian, began his professional career in 1941 as a co-op student, alternating between work with Hercules Powder Company and school at Alabama Polytechnic Institute. He served three years in the U. S. Navy during World War II, primarily as an engineering officer aboard the cruiser Miami in the Pacific Theater. In 1946 he returned to Auburn where he received the BS in chemical engineering in 1947. After two years as Quality Control Engineer with Hercules Powder Company, he entered graduate school at LSU and was awarded PhD (chemical engineering) in 1951. Since that time he has been a member of the faculty at Mississippi State University where he is presently Professor of Chemical Engineering.

Several summers have been spent in process engineering work with various industries in the South and Southwest. In the summer of 1958 he worked with Magnolia Natural Gas Department on the deethanizer performance studies.

He is a member of the American Chemical Society and AIChE and is at present Counselor for the Mississippi State University Student Chapter of AIChE. He holds membership in many honorary societies among which are Tau Beta Pi, Phi Kappa Phi, and Sigma Xi.

Out of necessity he has become an amateur architect and builder, having designed and built two homes. On such projects he has been ably assisted by his wife, Katharine (Jordan), and their four children, Katharine, 10, Jane, 9, John, 7, and Martha, 5.

temperature. This mean heat capacity can be determined from the enthalpies at two temperatures as shown by:

$$\bar{C}_{pm} = \int_{T_1}^{T_2} \frac{\bar{C}_p dT}{T_1 - T_2} = \int_{T_1}^{T_2} \frac{(a + bT)dT}{T_2 - T_1} = a + \frac{b}{2}(T_2 + T_1)$$

$$\bar{C}_{pm} = a + \frac{b}{2}(T_2 + T_1) = \frac{\bar{H}_2 - \bar{H}_1}{T_2 - T_1} = \bar{C}_p \text{ @ } T = \frac{T_2 + T_1}{2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Calculation of heat capacity by this integral method is preferable to differentiation of enthalpy with respect to temperature. Graphical differentiation by measurement of the slopes of enthalpy vs temperature curves is subject to large error and is not recommended.

Latent heats of vaporization of components are obtained by difference between vapor and liquid partial enthalpies, each evaluated at the molal average boiling point of the phase in which it occurs. A minimum of three values of latent heat is required to establish the constants in the type equation

$$\Delta\bar{H}_v = a' + b'T + c'T^2 \quad . \quad . \quad . \quad . \quad (4)$$

which is commonly used in computer calculations. $\bar{H}_v$ is the partial latent heat of vaporization and a′, b′ and c′ are constants.

The composition of the feed, overhead product and bottoms product along with equilibrium data and the enthalpy charts are sufficient to establish the heat capacity and latent heat relationships.

Partial latent heat determinations may be carried out as in Example 2. Partial heat capacity evaluation from enthalpy data is shown in Example 3. **Example 2.** The composition of bottoms product from a deethanizer is estimated to be 2.83 percent ethane, 37.25 percent propane, 16.66 percent isobutane and 43.26 percent n-butane at a pressure of 453 psig. Estimate the partial latent heats of vaporization of the components at reboiler conditions.

Comp.	X_i	$(Y_i = K_iX_i)$*	T_{Bi},R	X_iT_{Bi}	Y_iT_{Bi}	$\bar{H}_{iL}$	$\bar{H}_{iv}$	$\Delta\bar{H}_{vap}$
C_2	0.0283	0.050	332	9.4	16.6	5750	7350	1600
C_3	0.3725	0.465	416	155.0	193.4	4850	7700	2850
iC_4	0.1666	0.146	471	78.5	68.7	4900	8400	3500
nC_4	0.4326	0.339	491	212.4	166.6	4450	8700	4250
				455.3	445.3			

*Boiling point is 222 F

Example 3. Preliminary estimates of feed and product compositions on a deethanizer operating at 468 psia yield the following values of boiling point and molal average normal boiling point. Estimate the partial heat capacity of propane in the solutions at three temperatures.

Stream	B.P., F	MABP, F	$\bar{H}_{LCs}$, Btu/lb mole
(1) overhead (L)	71	-115	-1250
(2) Feed (L)	160	- 42	1950
(3) Bottoms (L)	222	- 4	4850

$$\bar{C}p \text{ @ } \frac{222 + 71}{2} = Cp \text{ @ } 146.5 \text{ F} = \frac{4850 - (-1250)}{222 - 71}$$
$$= 40.4 \text{ Btu/(lb mole) (F)}$$

$$\bar{C}p \text{ @ } \frac{222 + 160}{2} = Cp \text{ @ } 191 \text{ F} = \frac{4850 - 1950}{222 - 160}$$
$$= 47.6 \text{ Btu/(lb mole) (F)}$$

$$\bar{C}p \text{ @ } \frac{160 + 71}{2} = Cp \text{ @ } 115.5 \text{ F} = \frac{1950 - (-1250)}{160 - 71}$$
$$= 36.0 \text{ Btu/(lb mole) (F)}$$

Obviously, in fractionator calculation, these first approximations on heat content must be checked after compositions and temperatures have been established on the basis of the estimates. However the first assumptions arrived at in the manner described should be fairly good and no more than two trials should be necessary. Since the same trial and error procedure is required in evaluating equilibrium K values, the overall amount of calculations is not appreciably increased.

Nomenclature

a, b,	= constants in heat capacity equation
a′, b′, c′	= constants in latent heat equation
$\bar{C}p$	= partial molar heat capacity, Btu/(lb mole) (F)
$\bar{C}pm$	= average heat capacity between two temperatures
H	= mixture enthalpy, Btu/lb mole
H_i	= component partial enthalpy, Btu/lb mole
$\bar{H}_i$	= partial latent heat of vaporization, Btu/lb mole
K_i	= equilibrium ratio, Y_i/H_i
X_i	= mole fraction of a component in the liquid phase
Y_i	= mole fraction of a component in the vapor phase

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DISTILLATION . . .
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Part 1: Phase Equilibria and Thermodynamic Concepts

CHAPTER 2 — THERMODYNAMICS

Kenneth F. Gordon and **James A. Davies**
University of Michigan, Ann Arbor, Michigan — *The Texas Company, New York City*

GAS LAWS

A pressure-volume-temperature relationship is normally used for one of two purposes. Most often it is desired to estimate one variable of pressure, volume, and temperature when values for the other two are known. Here high accuracy is not normally required, five percent often being adequate as, for instance, in sizing equipment. The second purpose is to use the relationship to derive values of thermodynamic functions such as the Joule-Thompson coefficient and the variation of enthalpy, entropy, and specific heats with pressure or volume. Here the experimental data are often differentiated once or twice necessitating a much higher order of accuracy.

For the first purpose the ideal gas law or a generalized compressibility chart, available in most thermodynamic texts, will normally suffice. For the second purpose, where derivatives of the PVT data may be needed, great precision is required. As it is much easier to differentiate an algebraic equation than attempt to take the slopes of curves through data, it is usual to first correlate the experimental data by an algebraic equation of state, then differentiate the equation. There are a very large number of such equations that have been used by chemists and engineers, the better known including those of Van der Waals, Beattie-Bridgeman, Benedict-Webb-Rubin, and Martin-Hou. Only Van der Waals will be given here.

$$\left(P + \frac{a}{\bar{V}^2}\right)(\bar{V} - b) = RT \quad . \quad . \quad . \quad (1)$$

These will represent the data to various degrees of accuracy and allow fairly precise interpolation of the data and even extrapolation to some extent.

In their new book, Reid and Sherwood[20] present a critical comprehensive review of various equations of state and methods of determining one of p^o, V, or T when the other two are known. Both liquid and gas phase estimations are covered. This compilation of methods should be a standard reference for those who wish to make a survey of the possible routes before doing a calculation. Various methods and equations are compared for accuracy and range of applicability.

FREE ENERGY, FUGACITY, EQUILIBRIUM AND ACTIVITY COEFFICIENT

The role of thermodynamics in distillation is twofold. As discussed earlier, it allows energy balances to be made and equilibrium to be predicted. The "distance" from equilibrium may in turn be used to predict mass transfer rates, for it is nothing more than the potential or driving force of mass transfer.

Equilibrium data for distillation are difficult to obtain. The correlation of equilibrium data and its prediction are problems that often face the distillation engineer. While this is not a difficult problem in a system of straight chain hydrocarbons, it is very complex in highly imperfect solutions of polar, non-polar combinations involving, for instance, alcohols and hydrocarbons.

It is an empirical observation that the universe, as we know it, tends to run down as judged by irreversibilities, a continuous increase in entropy and a decrease in the availability of energy or work. Also, systems which tend to move spontaneously go in a direction where they might do work, if the system was either in or coupled to an apparatus which might extract work. A storage battery connected to a d-c electric motor and a windmill in a wind would be examples. Thus the ability to do work has become the criterion as to the feasibility of a contemplated change. At constant temperature and pressure it may be shown that the net reversible work is the negative Gibbs free energy, $-\Delta G$, where

$$\Delta G = \Delta H - T\Delta S \quad . \quad . \quad . \quad . \quad . \quad (2)$$

This is normally derived in thermodynamics texts. Often the symbol F is used instead of G for the Gibbs free energy. It follows that if a contemplated isothermal process at constant total pressure has a net negative Gibbs free energy change it is thermodynamically feasible. Under the less

common restriction of constant volume and temperature, the analogous remarks hold for the Helmholtz free energy. For phases in equilibrium, no net work is available in bringing an infinitesimal amount of one component from one phase to another and the free energy change for the process is zero. Thus the criteria for equilibrium between two states is that the change in free energy in taking an infinitesimal amount of component from one state to another is zero.

From the derivation of the Gibbs free energy it may be shown that at constant temperature, as indicated by the subscript T,

$$dG_T = VdP = PV\, d(\ln P) \quad . \quad . \quad . \quad . \quad (3)$$

This equation is exact but is not the most convenient form. A more useful form for an ideal gas is

$$dG_T = RT\, d(\ln P) \quad . \quad . \quad . \quad . \quad . \quad (4)$$

This is convenient but not general enough to be used for materials which do not follow the ideal gas law. A choice is now made between either writing a different equation for each non-ideal substance relating the free energy with the pressure at constant temperature or introducing a new function which, when substituted in place of pressure in the expression above, will give the desired change in free energy. The latter is chosen with the introduction of a function known as the fugacity. In a sense, it may be regarded as a corrected pressure. The equation becomes

$$dG_T = RT\, d(\ln f) \quad . \quad . \quad . \quad . \quad . \quad (5)$$

which is the defining equation for fugacity.

From the definition of fugacity it follows that the change in fugacity in going between two states in equilibrium must be zero if the free energy change is to be zero. The criteria of equilibrium at constant temperature then becomes the equality of the fugacity of each component in each phase. When integration of the defining equation for fugacity is made, it is usual to choose the constant of integration so that the fugacity approaches the absolute pressure as the pressure tends to zero, that is, when a gas approaches ideal behavior. The criteria for equilibrium between a real vapor and real liquid is, for component A,

$$f_{A,V} = f_{A,L} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

If the gases concerned follow the ideal gas law and form perfect gas solutions, then this stipulation becomes the equality of the partial pressures.

For the purposes of this paper an ideal gas is one which follows the equation

$$P\overline{V} = RT$$

and whose enthalpy is independent of pressure. A perfect solution, either liquid or gas, is one in which the fugacity of any component is equal to the product of the fugacity of the component in its pure state multiplied by the mole fraction of the component. From this definition it may be shown that there is no enthalpy of mixing and no volume change on formation of the solution from the components at constant temperature and pressure. Also the activity coefficient which is discussed below is unity.

The fugacity function is introduced to take into account the non-ideal behavior of the gas, that is, its deviation from $P\overline{V} = RT$. The fugacity does not correct the deviation resulting from non-perfect solutions forming in either liquid or vapor phase because of association or dissociation. To maintain the convenient form of the equations for ideal gases yielding perfect solutions in both gas and liquid phases the activity coefficient, γ, is introduced for each phase. The equilibrium relationships then become

$$\gamma_V y_A P = \gamma_L x_A P^\circ_A \quad . \quad . \quad . \quad . \quad . \quad (7)$$

for real solutions of ideal gases.

For a substance which is a real gas forming perfect liquid solutions, the fugacity must be used. This is clearly that of the pure liquid at the temperature in question but at which pressure W. K. Lewis and Luke [11] use the vapor pressure of the pure liquid while Souders, Selheimer and Brown [23] use the total pressure, in the method known as either the Brown or G. N. Lewis and Randall or perfect (ideal) solution method. Both are empirical and a choice cannot be made on the basis of theory. They are usually equivalent if the pressure is less than 100 psi.

From

$$\left(\frac{\partial G}{\partial P}\right)_T = V \quad . \quad . \quad . \quad (8)$$

and the defining equations for fugacity there follows:

$$\frac{f^\circ_{L,P^\circ}}{f^\circ_{L,P}} = e^{\frac{\overline{V}}{RT}(p^\circ - P)} \quad . \quad . \quad . \quad . \quad (9)$$

if $\overline{V}$, the liquid molal volume, is considered constant

The equilibrium relationships then become

$$\gamma_V y f_{V,P} = \gamma_L x f^\circ_{L,P} = \gamma_L' x f^\circ_{L,P^\circ} \quad . \quad . \quad (10)$$

for real solutions of real gases. The two values of the liquid activity coefficient, γ_L and γ_L', result from the two ways of estimating the fugacity of a substance as a pure liquid, $f^\circ_{L,P}$ being the fugacity evaluated at the total pressure and f°_{L,P° at the vapor pressure of the pure component in question. It is to be noted that if the liquid phase is considered to have negligible volume, the activity coefficients become identical.

The estimation of the various fugacities is straightforward. A fugacity chart, available in most thermodynamics texts is used. It is a generalized correlation of f/P against the reduced pressure with a parameter of reduced temperature. The ratio of fugacity to pressure of a pure component in the gas phase is read for the given reduced temperature at the reduced pressure. The latter is the ratio of the total pressure to the critical pressure of the substance of interest. The fugacity is then the product of the ratio f/P, from the chart, multiplied by the total pressure.

The fugacity of a pure component in the liquid phase is estimated in the same manner using the vapor pressure of the pure substance at the temperature of interest as the pressure, which, along with the critical pressure, gives the reduced pressure. The chart then yields f/P, which, when multiplied by the vapor pressure, gives an estimate of the fugacity. Multiplying this by the mole fraction in the liquid gives the estimated fugacity of a component in the liquid phase by the Lewis method. Allowance for the effect of ambient pressure on the fugacity can be made by Equation 9 which gives an estimate of the fugacity by the Brown method. Sage and Lacey have presented a comparison of experimental results with those calculated on the basis of Raoult's Law, the W. K. Lewis method and perfect solution method.[22] For the methane-n-butane and propane-n-butane systems, the Lewis method appears to be best.

Gilliland and Sullivan [4] have discussed the estimation of the fugacity of a component in a vapor phase mixture reviewing various rules and methods and comparing the estimated results to their experimental data for ethylene in various mixtures. For ethylene in hydrogen they show that at a pressure of 272 atmospheres the perfect solution method is off by a factor of three while that of Kritschewsky

and the isometric method are much better, while the partial molal and Bartlett's methods are poor.

RAOULT'S, DALTON'S AND HENRY'S LAWS

If we have a system of components which all obey the ideal gas law and in addition form a perfect gas solution, ($f_{A,V} = p_A$ and $\gamma_{A,V} = 1$), then Dalton's Law holds.

$$p_A = y_A P \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

If in addition the components form perfect liquid solutions ($\gamma_L = 1$) as is approximated by isotopes and a homologous series of hydrocarbons, then Raoult's Law also holds.

$$p_A = x_A p^\circ_A \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

For a real gas forming perfect solutions the fugacity must be used instead of the pressure yielding $y_A f^\circ_A P = x f^\circ_A p^\circ$ as one approximation.

In dilute imperfect solutions the activity coefficient of the solute will often be constant over a concentration range, while its activity coefficient in the gas phase is unity and the gases are ideal allowing the equation for physical equilibrium to be written

$$p_A = \gamma_{A,L} p^\circ_A x_A = H' x_A = \frac{H'}{\rho_M} c_A = H c_A \quad . \quad (13)$$

where H is a constant known as the Henry's Law constant. Often the equation is written defining the constant as the reciprocal of the one defined here.

EQUILIBRIUM RATIO AND RELATIVE VOLATILITY

A very convenient form of an equilibrium equation between a liquid and gas is

$$y = \frac{\gamma_L}{\gamma_V} \frac{f^\circ_{A,L,P}}{f^\circ_{A,V,P}} x = \frac{\gamma'_L f^\circ_{A,L,P^\circ}}{\gamma_V f^\circ_{A,V,P}} x = Kx \quad . \quad . \quad . \quad (14)$$

where K is known as the equilibrium ratio and would be expected to vary with both pressure and temperature as the activity coefficient and fugacities change. As a first approximation it might be regarded as independent of composition, but it is known to be a function of the composition as well. The equilibrium ratio is sometimes known as the equilibrium constant, but this notation is less desirable because this constant varies.

A popular method of correlating equilibrium data for a paraffinic series of hydrocarbons employs the equilibrium ratio and the convergence pressure. A plot of log K vs log P at constant temperature is sketched in Fig. 1 for a binary system. The common pressure at which the value of K for each component becomes unity is the critical pressure for the particular temperature. In some multicomponent systems, such as a series of paraffinic hydrocarbons, it is found that for a given temperature the K's for all components appear to converge to unity at a common pressure known as the convergence pressure. Only if the temperature happens to be the critical temperature for the system will this be the critical pressure.

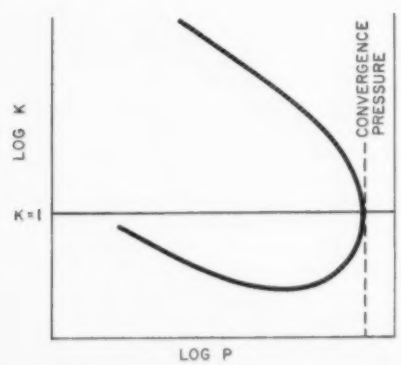

FIG. 1. Equilibrium ratio versus total pressure.

NOMENCLATURE

A, a, b, c	Constants
C	Number of components
c	Concentration
F	Degrees of freedom in phase rule
f_A	Fugacity of component A
f°_A	Fugacity of component A in pure state, real or hypothetical
G	Gibbs Free Energy
$\overline{G}$	Partial molal Gibbs Free Energy
H	Enthalpy or Henry's Law Constant
K	Equilibrium ratio y/x
L°	Partial molal enthalpy of solution of a pure component at infinite dilution
P	Total pressure
p_A	Partial pressure of component A
p°_A	Vapor pressure of component A in pure state
R	Gas law constant
S	Entropy
T	Temperature, absolute
V	Volume
$\overline{V}$	Partial molal volume or specific volume
x	Mole fraction liquid phase
y	Mole fraction vapor phase
Subscripts	
A, B, 1, 2	Component
L	Liquid phase
V	Vapor phase
T	Constant temperature
P	Total pressure
Superscripts	
E	Excess function
M	Mixing function
°	Pure component
–	Partial molal or specific quantity
Greek Letters	
α	Volatility ratio
Δ	Difference
γ	Activity coefficient
ρ_M	Molal density
ϕ	Function

It has been discovered that the convergence pressure can be used as a parameter to characterize the composition of the system under consideration. For a given component, say hexane, a plot of log K against P with a parameter of temperature can be prepared for a mixture with a given convergence pressure such as 600 psia. A series of K charts are available for a number of substances, methane through decane, each chart being for a different convergence pressure over the range 600 to 20,000 psia.[12,13] A good bibliography is included in this set of charts provided by the Natural Gasoline Supply Men's Association (NGSMA) and the Natural Gasoline Association of America (NGAA). These charts are based on experimental data. Recently Norman and Williams [14] have put these charts in the form of equations suitable for machine computation. Another recent article by Lenoir discusses convergence pressures for non-perfect solutions [10] while an earlier one by Hadden [6] presents methods for calculating convergence pressures for

hydrocarbons which are given with the NGSMA and NGAA charts.

The convergence pressure of a mixture can be obtained by assuming it to be a binary of the lightest component and a pseudo-component consisting of the remainder. The pseudo-component is characterized by the weight average critical temperature and pressure of its own constituents. At a given temperature, the convergence pressure of any binary is its critical pressure. This leads to the concept that the convergence pressure of the pseudo-binary is its critical pressure which can be taken from the estimated critical locus plot for the pseudo-binary. The critical locus is usually plotted as the logarithm of the total pressure against temperature. The position and shape of this curve is obtained by interpolation of the curves for real binary systems of the lightest component and hydrocarbons with criticals on either side of the pseudo-component.

To obtain the convergence pressure of a hydrocarbon mixture, an estimate of the liquid phase composition must be made. If the system under consideration is a two phase system with known total composition, this is done by trial. A convergence pressure is first assumed allowing values of K to be obtained from the K-charts mentioned above which give log K against pressure with a line for each temperature and a chart for each component and each convergence pressure. From these values of K, the composition of the liquid phase is calculated by the standard techniques for flash calculations. For the computed liquid phase composition, the weight average critical temperature and pressure is calculated. On a chart giving the critical loci of a large number of binary mixtures, the critical loci of the pseudo-binary is sketched by interpolation between the curves of binaries of the light component with hydrocarbons of various criticals. Such a chart is available with the K charts of the NGAA and NGSMA. At the given temperature, the critical pressure for the pseudo-binary is read and taken as the convergence pressure. With this value for convergence pressure the appropriate K charts can be read. If the convergence pressure is greatly different than that used to estimate the liquid composition, the calculation should be repeated with a better estimate of the convergence pressure.

In any system the ratio of the equilibrium ratios K_A/K_B will often be approximately constant over the range of temperature of a constant pressure equilibrium diagram. This allows a simple equation for equilibrium to be developed readily for binary systems:

$$y_A/x_A = K_A \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

and

$$y_B/x_B = \frac{1-y_A}{1-x_A} = K_B \quad . \quad . \quad . \quad (16)$$

Letting $\alpha = K_A/K_B$, the relative volatility, then

$$y_A = \frac{\alpha x_A}{1+(\alpha-1)x_A} \quad . \quad . \quad . \quad . \quad (17)$$

For ideal gases and perfect gas and liquid solutions

$$K_A/K_B = p^\circ_A/p^\circ_B \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

while for real gases with real solutions

$$\alpha = K_A/K_B = \frac{\gamma_{AL}f^\circ_{A,L,P}}{\gamma_{AV}f^\circ_{A,V,P}} \cdot \frac{\gamma_{BV}f^\circ_{B,V,P}}{\gamma_{BL}f^\circ_{B,L,P}}$$

$$= \frac{\gamma'_{AL}f^\circ_{A,L,p^\circ}}{\gamma_{BV}f^\circ_{B,V,P}} \cdot \frac{\gamma_{AV}f^\circ_{A,V,P}}{\gamma'_{BL}f^\circ_{B,L,p^\circ}} \quad . \quad . \quad . \quad (19)$$

Even if α varies slightly with temperature it is often sufficient to take an average value as a constant over the whole range to obtain the equilibrium curve. It should be emphasized that good data are always preferable to estimated values from a correlation or calculation. For an azeotrope where $x = y$, both K and α are unity.

CORRELATING EQUATIONS

It is desirable to have equations giving the deviations from ideal solutions as functions of a very few constants which, in our present state of knowledge, would be evaluated from experimental data. It would be hoped that eventually these constants could be correlated with physical properties.

A strong step in this direction is given in a recent article by Pierotti, Deal and Derr [16] who give equations for the activity coefficients at infinite dilution in terms of the number of carbon atoms in the solute and solvent, as well as the number of rings and number of carbon atoms in the ring and paraffin part of a ringed structure solvent. The constants for the terms of the equations are given for various homologous series in different solvents. The average deviation from the experimental results for the log γ at infinite dilution is 3 percent for 44 sets of systems and the average deviation in γ is 8 percent. New data for 275 binary systems are available through the American Documentation Institute. The utility of values of the activity coefficients at infinite dilution will become apparent in the latter part of this section.

A thermodynamic relationship known as the Gibbs-Duhem equation is very useful in this task. Its development is available in a number of texts [5,6,8,26] and will be outlined here.

First the concept of partial molal quantities must be examined. Consider volume which is an extensive property, meaning its magnitude depends on the amount of material considered. In contrast, density which does not depend on the quantity considered is known as an intensive property. If the volume of an ethanol-water mixture be followed as ethanol is added to water it will be found that the rate of increase of volume of the mixture per unit amount ethanol added is a function of concentration and is given by

$$\overline{V} = \left(\frac{\partial V}{\partial n_A}\right)_{n_B,\,P,\,T} \quad . \quad . \quad . \quad . \quad (20)$$

where $\overline{V}$ is by definition the partial molal volume of ethanol at a total pressure P, temperature T and with a fixed amount of water, n_B, present.

Imagine a given solution of ethanol-water to be made by alternately adding ethanol and water to the container so that the concentration is always very close to the final concentration. The gain in volume as each increment of ethanol is added may be obtained from the product of the partial molal volume of ethanol and the amount of ethanol added and similarly for the water. As the concentration is always very close to the final concentration the value of the partial molal volume for each component will remain essentially constant throughout the process.

It will follow that the total volume of the resulting mixture will be the sum of the volume contribution of each component and is given by the equation

$$V = n_A\overline{V}_A + n_B\overline{V}_B \quad . \quad . \quad . \quad . \quad (21)$$

Similar equations may be developed for other extensive properties such as enthalpy and entropy. It is to be noted that the volume of the mixture is not equal to the sum of the volumes of the unmixed components.

For an open system of two components the total Gibbs free energy of the system is a function of the pressure, temperature and the amount of each component n_A and n_B.

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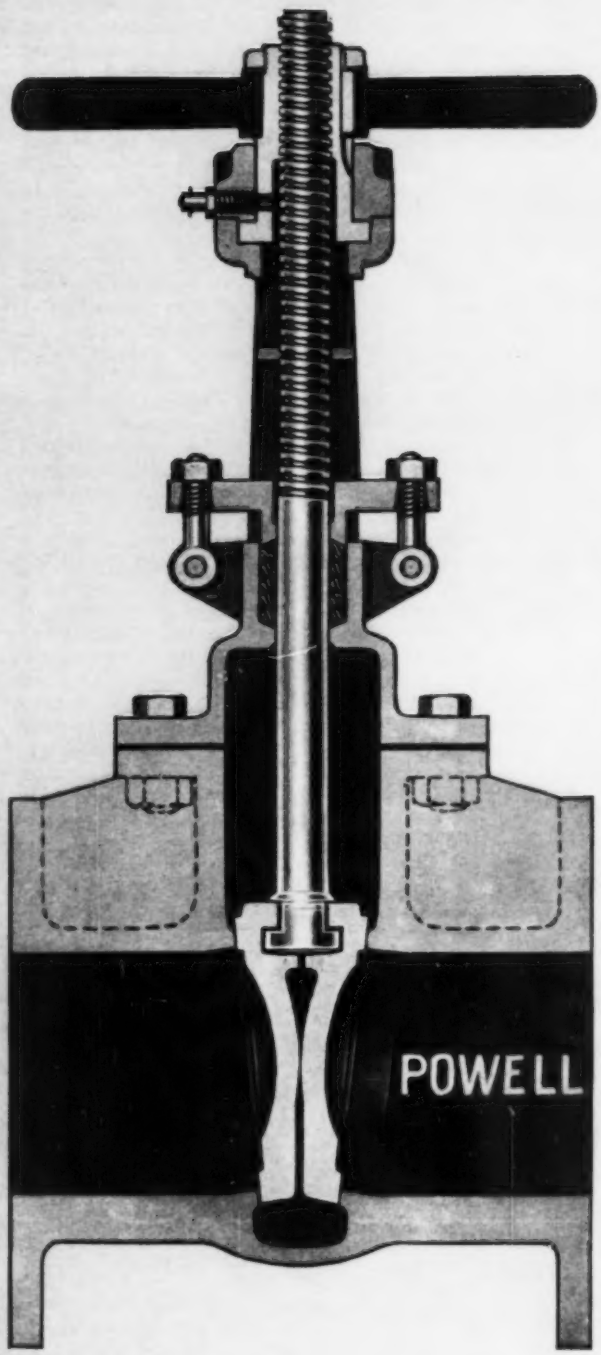

Fig. 2453 DG (Sectional)—Large Stainless Steel O.S.&Y. Gate Valve. Available with interchangeable solid or split wedges. Wedges are fully guided throughout their travel.

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Fig. 2633—Large, Stainless Steel Swing Check Valve for 150 W.P. Sizes, 2" to 12".

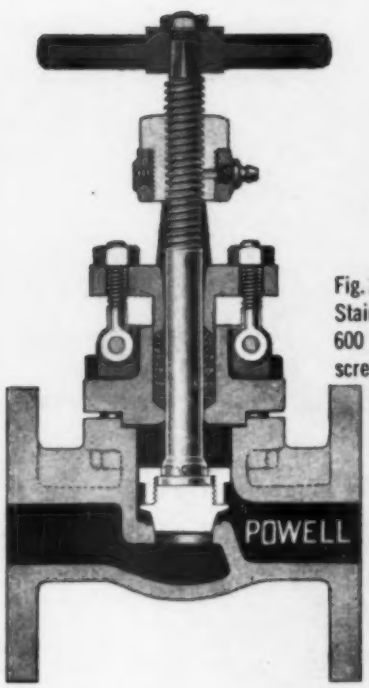

Fig. 2475 (Sectional)—150 W.P. O.S.&Y. Stainless Steel Globe Valve. 300 and 600 W.P. also available. ¼" to 3"—screwed and flanged ends.

Fig. 2106 (Sectional)—150 W.P. O.S.&Y. Stainless Steel "Y" Valve. ¼" to 3"—screwed and flanged ends. 300 W.P. valves also available.

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By open it is meant that material and energy can be added to the system. Symbolically for the Gibbs free energy

$$G = \phi(P, T, n_A, n_B) \quad . \quad . \quad . \quad . \quad (22)$$

In differential form

$$dG = \left(\frac{\partial G}{\partial P}\right) dP + \left(\frac{\partial G}{\partial T}\right) dT + \left(\frac{\partial G}{\partial n_A}\right) dn_A + \left(\frac{\partial G}{\partial n_B}\right) dn_B \quad . \quad . \quad . \quad . \quad . \quad (23)$$

$$= VdP - SdT + \overline{G}_A\, dn_A + \overline{G}_B\, dn_B \quad . \quad . \quad . \quad (24)$$

and at constant temperature and constant total pressure

$$dG_{T,P} = \overline{G}_A\, dn_A + \overline{G}_B\, dn_B \quad . \quad . \quad . \quad . \quad (25)$$

By reasoning similar to the development of Equation 21

$$G = n_A\overline{G}_A + n_B\overline{G}_B \quad . \quad . \quad . \quad . \quad . \quad (26)$$

The next step appears to give something for nothing but can be shown to be mathematically legitimate by Euler's Theorem on Homogeneous Functions. By differentiating Equation 26 and substituting Equation 25 there results

$$0 = n_A\, d\overline{G}_A + n_B d\overline{G}_B \quad . \quad . \quad . \quad . \quad . \quad (27)$$

$$= n_A\, RT\, d(\ln f_A) + n_B\, RT\, d(\ln f_B) \quad . \quad . \quad . \quad (28)$$

Dividing by $(n_A + n_B)$ RT it follows that

$$x_A d(\ln \gamma_A) + x_B\, d(\ln \gamma_B) = 0 \quad . \quad . \quad (29)$$

Substituting $f_A = \gamma_A x_A f^o_A$ and remembering that f^o_A is a constant so its derivatives are zero, that $x_A d(\ln x_A) = dx_A$ and for a two component system $dx_A + dx_B = 0$, there results

$$x_A d(\ln \gamma_A) + x_B\, d(\ln \gamma_B) = 0 \quad . \quad . \quad (30)$$

or

$$x_A \frac{d(\ln \gamma_A)}{dx_A} = -x_B \frac{d(\ln \gamma_B)}{dx_A} \quad . \quad . \quad (31)$$

Strictly speaking this equation is only good for the condition of constant temperature and pressure but it is often used to test for thermodynamic consistency equilibrium data taken at constant pressure and variable temperature. Knowing the activity coefficient of one component in a two component system as a function of concentration the activity of the other component as function of concentration may be readily obtained from the integration of Equation 31. Examples of such calculations are available.[19]

Herrington [7] has presented a method for testing activity coefficients. While based on the Gibbs-Duhem equation it takes into account the change in temperature at constant pressure for a two component system.

It is clear that for thermodynamic consistency the experimental values of the activity coefficient for a two component system should satisfy the Gibbs-Duhem equation. This requirement is used to reduce the constants in an empirical representation of the activity coefficient.

a. **Margules Equation.**

Here the activity coefficients for a two component system are empirically represented by

$$\ln \gamma_1 = ax_2 + bx_2^2 + cx_2^3 \quad . \quad . \quad . \quad (32)$$

$$\ln \gamma_2 = a'x_1 + b'x_1^2 + c'x_1^3 \quad . \quad . \quad . \quad (33)$$

As is customary in this field the subscripts 1, 2, etc. refer to different components A, B, etc. Notice that the activity of the first component is given in terms of a power series of the concentrations of the second in order to allow the activity coefficient of a pure component to be unity.

Substituting into the Gibbs-Duhem equation it will be found that certain relationships between the coefficient a, b, and c and a′, b′, and c′ are necessary and the Margules equations become

$$\frac{\ln \gamma_1}{x_2^2} = b + cx_2 \quad . \quad . \quad . \quad . \quad (34)$$

$$\frac{\ln \gamma_2}{x_1^2} = b + c(0.5 + x_2) \quad . \quad . \quad . \quad (35)$$

It is seen that the Margules equation does not indicate the effect of temperature on the constants b and c and the activity coefficient. This is sometimes handled by incorporating a multiplying term of the absolute temperature raised to a power in front of the logarithmic terms in each equation. The correction for temperature is also discussed below.

More useful might be equations with a derived temperature term in the equations rather than an empirical correction term in front. Such equations are the Van Laar equations, which like the Margules equations are also integrated forms of the Gibbs-Duhem equation. It is clear that there are an infinite number of integrated forms of the Gibbs-Duhem equations.

b. **Van Laar Equations.**

To understand the philosophy behind Van Laar's derivation and some recent developments in equilibrium it is necessary to be familiar with the concept of excess functions. Consider volume; if two pure components are mixed to form a solution the final volume may be different than the sum of the volumes of the two pure components. The volume of mixing can be defined as

$$V^M = V - x_1V_1^o - x_2V_2^o \quad . \quad . \quad . \quad (36)$$

Similar definitions follow for other extensive properties such as enthalpy, free energy and entropy as well as for intensive properties such as heat capacity and the specific properties of volume, enthalpy, entropy and free energy.

The excess volume is the actual volume of mixing less the volume of mixing for an ideal solution and similar definitions are made for enthalpy, entropy and free energy of mixing. A perfect solution is one in which there is no enthalpy or volume of mixing so that for a real solution the excess volume is equal to the volume of mixing and the excess enthalpy is equal to the enthalpy of mixing.

A perfect solution can be defined as one whose free energy of mixing is given by

$$G^M = RTx_1(\ln x_1) + RT\, x_2(\ln x_2) \quad . \quad . \quad (37)$$

and the entropy of mixing is given by

$$S^M = -Rx_1(\ln x_1) - Rx_2(\ln x_2) \quad . \quad . \quad (38)$$

In a perfect solution all thermodynamic mixing functions will be zero except those containing entropy like free energy or entropy itself.

Van Laar assumed that $\Delta S^E = \Delta V^E = 0$ where the superscript designates an excess function and that the Van der Waals equation holds and obtained equations known as the Van Laar equations. Cooper[2] obtained the same result by assuming that G^E/V was proportional to the product of the volume fractions of the two pure components while Scatchard [23] has obtained a similar equation. The Van Laar equations are

$$T(\ln \gamma_1) = B\left(1 + A\frac{x_1}{x_2}\right)^{-2} \quad . \quad . \quad . \quad (39)$$

$$T(1n\ \gamma_2) = AB\left(A + \frac{x_2}{x_1}\right)^{-2} \quad . \quad . \quad . \quad (40)$$

The Van Laar equations have one apparent useful advantage in that they incorporate the absolute temperature in the expression for the activity coefficient and thus allow an estimate of the effect of temperature by assuming that the constants in the equation do not depend on temperature. This is a rather poor assumption in many cases. A sounder way of handling the temperature is discussed below. The text by Robinson and Gilliland [21] show the deviations from the experimental data of the values of mole fraction in vapor phase calculated by the Van Laar and Margules equations. It is clear that as both sets of equations have two constants two values of activity coefficients are needed to evaluate the constants. A single value of an azeotrope composition along with the total pressure and the vapor pressures of the pure components at the same temperature will give the values of the constants. The activity coefficient of the liquid phase can be readily calculated assuming the gas phase activity coefficient is unity. If no fugacity correction is required so that the fugacities are equal to the pressures then:

$$yP = \gamma_L p^o x \text{ will yield } \gamma_L = P/p^o \quad . \quad . \quad (41)$$

This equation applied to each component will give a value of the activity coefficient of each component which in turn will allow the two constants of both the Margules and Van Laar equations to be evaluated from one measurement, namely the azeotropic composition. If the vapor phase does not follow the ideal gas law then fugacities would be used rather than vapor pressures. With the constants for the Margules equation the activity coefficient can then be calculated as a function of composition and with the Van Laar equation as a function of both composition and temperature. Examples of this are available.[20,21] Sometimes there is poor agreement between the values so calculated and experimental data. Attempts to develop the Van Laar equations to ternary and multicomponent systems are discussed in the two previous references.

Wohl [27] has written a thorough paper dealing with activity coefficients. This is based on the q-concept where a quantity, q, is associated with each component and z, the mole average of q, for each component is introduced. The excess free energy is then written in terms of q's and z's which in turn yields equations for the logarithm of the activity coefficient. The q-equations used go up to five suffixes with a five suffix equation having terms of 1, 2, 3, 4 and 5 suffixes. The number of suffixes is determined by the number of terms in the concentration terms associated with a constant, thus, $a_{11222}x_1^2x_2^3$, $a_{11122}x_1^3x_1^2$ and $a_{11112}z_1^4z_2$ are five-suffix terms and $a_{112}x_1^2x_2$ is a three suffix term while q_1x_1 is one suffix. For certain values of constants the q equations reduce to Margules and Van Laar equations of various complexities. Plots are given comparing the shapes of the curves of various equations. The concept is extended to ternary systems.

In addition to the above paper Wohl [28] makes a correction and gives a symmetrical form for the equations of excess free energy and activity coefficients in a ternary system for the case of both three and four suffix equations.

c. **Calculating the Constants.**

For ease of use and interpretation, the forms of the Margules and Van Laar binary system equations given in Perry's handbook [15] are best.

Margules

$$\log \gamma_1 = x_2^2\,[A_{12} + 2x_1\,(A_{21} - A_{12})]. \quad . \quad . \quad (42)$$

$$\log \gamma_2 = x_1^2\,[A_{21} + 2x_2\,(A_{12} - A_{21})]. \quad . \quad . \quad (43)$$

Van Laar

$$\log \gamma_1 = A_{12}\left(1 + \frac{A_{12}x_1}{A_{21}x_2}\right)^{-2} \quad . \quad . \quad . \quad (44)$$

$$\log \gamma_2 = A_{21}\left(1 + \frac{A_{21}x_2}{A_{12}x_1}\right)^{-2} \quad . \quad . \quad . \quad (45)$$

In both cases

at $x_1 = 0$	$\log \gamma_1 = A_{12}$ $\log \gamma_2 = A_0$	at $x_2 = 0$	$\log \gamma_2 = A_{21}$ $\log \gamma_1 = A_0$

The constants A_{12} and A_{21} are nothing more than the values of the logarithms of the activity coefficient at infinite dilution. While both constants can be calculated from a single observation of the temperature, total pressure and composition of each phase at an intermediate composition, it is best to have experimental data over the whole composition range in order to check the validity of the correlating equations. It is sometimes found that the constants are nearly the same for similar systems. For example, the constants for the butane-benzene system might be expected to be similar to those for pentane-benzene.

The effect of temperature on the constants is covered in Perry. For systems where the values of log γ at infinite dilutions yield the constants, the effect of temperature is given by

$$\frac{dA_{12}}{d(1/T)} = -\frac{L_1^o}{2.3R} \quad . \quad . \quad . \quad . \quad . \quad (46)$$

$$\frac{dA_{21}}{d(1/T)} = -\frac{L_2^o}{2.3R} \quad . \quad . \quad . \quad . \quad . \quad (47)$$

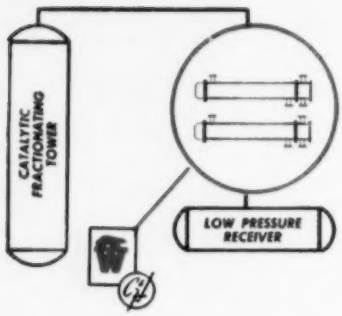
where L_1^o is the partial molal enthalpy of solution of component 1 at infinite dilution. To go from one temperature graphical integration would normally be required. L_1^o is usually a strong function of temperature and, unfortunately, data are often lacking.

Both Van Laar's and Margules' equations are employed for the correlation of data. As each can be corrected for variation in temperature, the choice between them is a matter of experience. In binaries, Van Laar's equation seems to fit the data more often. The part of Perry [15] dealing with activity coefficients, based on the work of Carlson and Colburn,[1] indicates that when the constants A_{12} and A_{21} differ by a factor of 2 or more, the Van Laar equations are best for those of approximately equal molal volumes. In our own experience, Van Laar's equations seem to fit the data more frequently than Margules but in highly imperfect solutions those of Margules are better. Fits of the data by both equations can be attempted with very little extra work. The Margules equations can be fitted readily to ternary systems and can be used for quaternary systems while the Van Laar equations are difficult to apply. They become rather lengthy, but are available for the two suffix case in Perry.

The use of the Margules equations for correlating data for three and four component systems has been discussed by Jordan, Gerster, Colburn, and Wohl [9] in connection with their work on the quaternary system of isobutane, butene-1, furfural and water. From their data, they derive values for the single ternary constants of a given system at each of several temperatures using the values of the binary constants and the ternary data. They show how a quaternary system may be handled as a pseudo-ternary system by combining two components as a single pseudo-component. Constants are obtained for a given ratio of the two components of the pseudo-component.

d. **Other Equations.**

Redlich and Kister [18] have presented a method of correlating experimental data which allows for changes in



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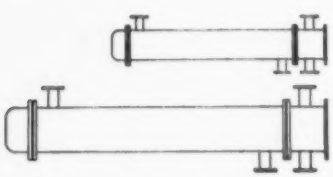

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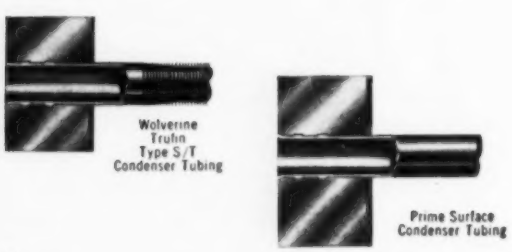

3

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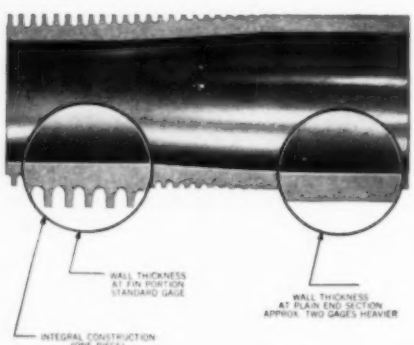
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Process scheme can be varied to allow for pre-fractionation of isomers in feed, and recycle of unconverted material. Selection depends, of course, on feedstock quality and degree of upgrading required.

Flow plan shown is for desulfurized pentane-hexane feed. Mixed feed is joined in the deisopentanizer by the pentane isomerization product. Isopentanes in the fresh feed and reactor effluent are taken overhead as product and the bottoms sent to the reactor. Hydrogen-rich gas is charged to the reactor with feed, is separated from the effluent for recycle. Only a small amount of make-up hydrogen is required. Reaction product from the separator is debutanized and depentanized.

Hexanes are isomerized once-through, with only a small incremental investment over pentane isomerization alone. Further upgrading is possible by adding a deisohexanizer and an auxiliary depentanizer to remove isohexanes in feed or to give full recycle of normal hexane in the product.

FEEDSTOCK AND PRODUCTS: Table below is based on processing three light naphthas from varying crude sources, based on experimental data from processing pentanes and hexanes.

	Kuwait		Mid-Continent		Nat. Gasoline	
TOTAL C5-C6	Feed	Product	Feed	Product	Feed	Product
Vol. %	100.0	98.6	100.0	98.3	100.0	99.2
Octane No. CFRR — Clear	64.1	79.0	63.0	78.0	73.0	85.7
+ 3 cc TEL	88.2	96.0	86.5	95.0	93.4	99.6
ISOPENTANE FRACTION						
Vol. % of total	45.0	45.0	34.5	34.5	58.5	58.5
Octane No. CFRR — Clear	74.4	92.0	72.9	92.0	79.2	92.0
+ 3 cc TEL	95.8	104.0	94.5	104.0	98.0	104.0
ISOHEXANE FRACTION						
Vol. % of total	55.0	53.6	65.5	63.8	41.5	40.7
Octane No. CFRR — Clear	55.9	68.0	57.7	70.5	64.0	76.4
+ 3 cc TEL	82.0	89.0	82.3	90.0	86.8	93.5

OPERATING PERSONNEL: One-two men per shift.

ECONOMICS: Investment for a 1500 BPD unit processing pentanes only would be about $825,000. Adding 1600 BPD capacity for hexanes to this unit would bring investment to about $1,100,000. Addition of deisohexanizer, recommended for feeds with high isohexane content, would cost about $225,000.

ECONOMICS OF ISOMERIZATION OF KUWAIT PENTANES AND HEXANES

Case	I*	II**	III***	IV****
Product Octane No.				
CFRR — Clear	90.9	79.0	79.8	90.9
+ 3 cc TEL	102.2	96.0	96.7	102.2
Capacity — B/D	1495	— 3100 —		3500
Process Investment	$825,000	1,100,000	1,425,000	1,475,000
Direct Operating Cost — ¢/bbl.	24	16	22	21
Payout, years	1.4	1.4	1.8	1.0
Cost, ¢/RONB†	10.6	7.6	8.4	9.6

*Recycle isomerization of normal pentane cut containing 7.0 vol. % hexanes.

**Isomerization of mixed pentane-hexane, recycle operation on the normal pentane, once-through on the n-hexane. No deisohexanizer.

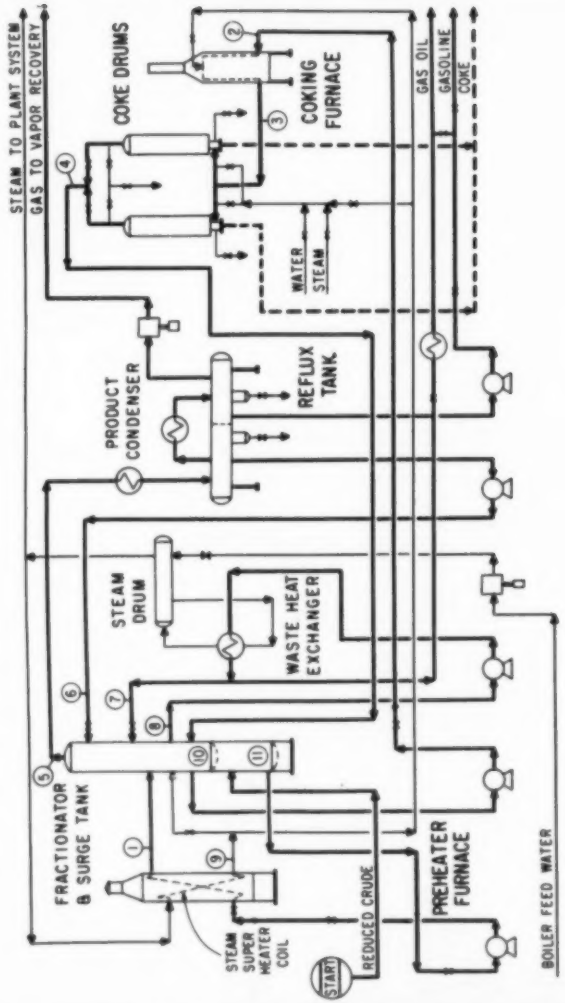
***Same as Case II but including deisohexanizer.

****Same as Case I but at increased throughput.

†¢/RONB based upon 93 CFRR + 3cc TEL pool gasoline.

Low Pressure Decarbonizing

Licensed by: Blaw-Knox Company, Chemical Plants Division



The Refining Engineer's Process Notebook

Low Pressure Decarbonizing

Licensed by: Blaw-Knox Company, Chemical Plants Division

DESCRIPTION: Process is designed for production of maximum coker gas oil for catalytic cracking and minimum coke and coker gasoline. Coking takes place at relatively low pressure to obtain this desirable yield structure.

The version of the process shown on the flow plan includes a combination feed and products fractionator so that atmospheric reduced crude can be processed. Only product fractionation would be needed where vacuum distillation capacity is already installed.

Two coke drums are used with one on the coking cycle and the other on the decoking cycle at any given time.

Coke is removed by means of a hydraulically-powered drill moving up through the coke bed. Actual decoking requires about three hours for a three-man crew; another four hours is required for unheading, heading up and clean-up.

Operating conditions and flow sequence is shown on the flow diagram. Additionally it should be noted that the unit produces its own steam requirements from a generator used to cool a fractionator pump-around stream.

Unique feature of the process is use of a vertical tube heater for the coker furnace. A special steam injection system makes this possible.

NORMAL SERVICE FACTOR: 95 Percent

UTILITIES	Per B Feed*
Net Steam	None
Power	1.2 kwh
Cooling Water	830 gal
Fresh Water	5 gal
Direct Fuel	0.18 MM Btu

*Based on coking of atmospheric-reduced crude.

INVESTMENT (U. S. Gulf Coast, 1957)

Capacity, B/SD	M $*
5,000	1,250
10,000	1,850
20,000	2,800

*On-site investment only, based on coking of atmospheric-reduced crude.

TYPICAL FEEDSTOCK AND YIELDS are shown in the table below, based on an East Texas reduced crude processed according to the flow diagram given. The coker furnace charge gravity is 12.5 API.

	Reduced Crude	Gasoline	Coker Gas Oil
API Gravity	26.6	54.0	28.6
Con. Carbon %	3.62	—	—
Sulfur, Wt. %	0.436	0.12	—
RON-0cc	—	52.6	—
Pour Point	80°	—	—
RVP	—	2.8	—
ASTM Distillation			
IBP	264	150	455
10%	510	238	571
50%	684	326	727
90%	—	380	890
EP	—	409	—
Recovery	100%	98.5%	97.5%
K UOP	11.85	—	11.93
SSU at 100	213	—	—
Bromine #	—	28.1	—

Catalytic Cracking Yields on Decarbonized Gas Oil

— Pilot Plant, Once Through Basis. —	Wt%	Vol%	°API
H_2S	0.2	—	—
C_3	6.9	—	—
C_4	7.4	11.2	—
Debut. Gaso.	34.5	41.0	59
Lt. Cycle	30.9	31.0	29
Hvy. Cycle	12.4	12.0	24
Catalyst Deposit	7.7	—	—

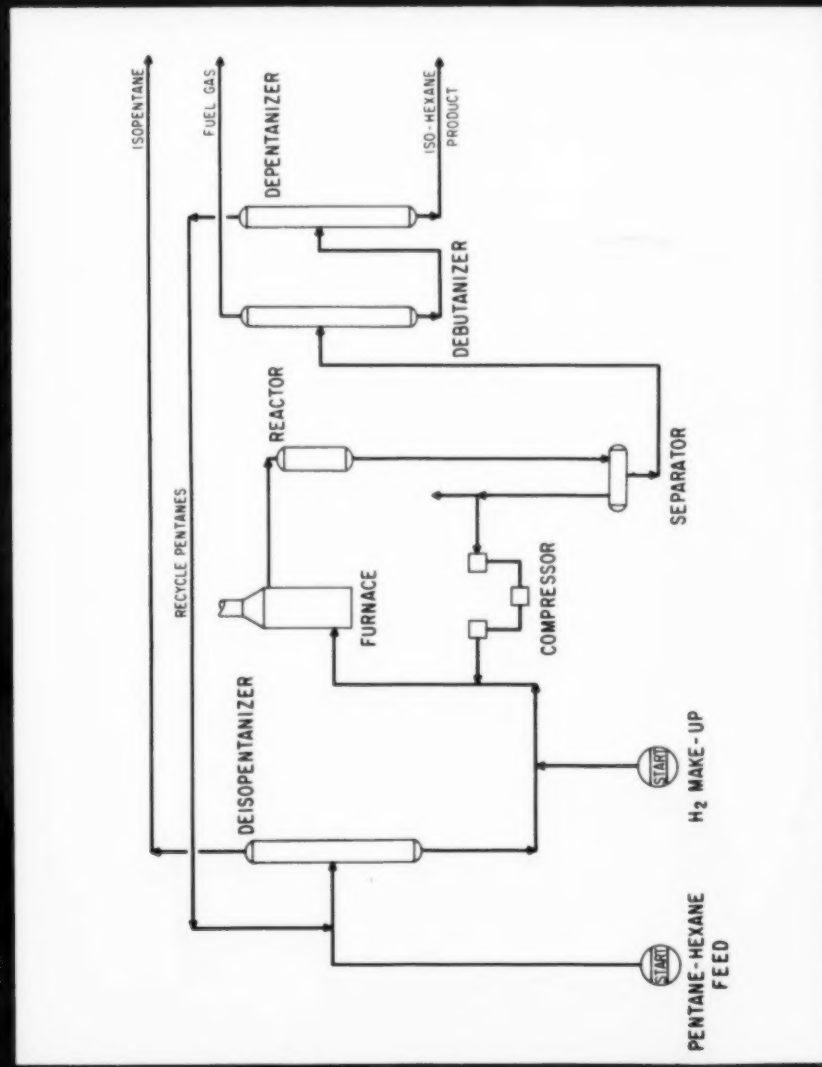
OPERATING PERSONNEL — Three men per shift for process operations, plus three men per day for decoking.

ANNUAL MAINTENANCE—Roughly 5 percent of plant investment for maintenance material and labor.

Reference: Low Pressure Coking Successful, The Refining Engineer, March 1958. Page C-46.

ISO-KEL Isomerization Process

Licensed by: The M. W. Kellogg Company



temperature. Two examples are included. In a second paper [19] they develop a power series for the excess free energy showing how the first three constants can readily be calculated from values for log γ_1/log γ_2 at certain characteristic points. The idea is extended to multicomponent systems with an example being given for the n-heptane-methanol-toluene system where the data for the ternary system can be predicted accurately from an equation including only terms resulting from the data for the three binary systems and none from the ternary.

Reid and Sherwood [20] devote a full chapter of their new book to an excellent review of the various ways of correlating and testing vapor-liquid equilibria data. They outline a number of the methods and present a good set of references for both binary and ternary systems.

A recent text, "The Molecular Theory of Solutions," by I. Prigogine [17] covers a number of developments in the whole field of solutions and is required reading for those interested in the theory of this area. It also includes some references to recent papers but will be of greater interest to the physical and theoretical chemist rather than to the practicing engineer.

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Atlantic Refining Unveils $18,000,000 Wax Plant

Overall view of processing plant.

"Nerve Center" of the wax plant.

The Atlantic Refining Company recently unveiled one of the world's largest paraffin wax manufacturing plants at its Philadelphia refinery. Built at a cost of $18,000,000, including auxiliary facilities, the new plant will increase Atlantic's paraffin wax production capacity by more than 80 percent.

Designed and built by the Badger Manufacturing Company of Cambridge, Massachusetts, the plant employs the Methyl Ethyl Ketone solvent dewaxing process. It covers an area of more than four acres and has a daily output of approximately 265 tons of wax.

This new installation is another milestone in Atlantic's history as a manufacturer of petroleum waxes. The company first began making wax in 1876 and has since pioneered many advances in wax technology, including the first successful wax expressly manufactured for milk cartons. The new plant will increase Atlantic's supply of paraffin wax for manufacturers of such products as candles, crayons, phonograph records, explosives, and a variety of food wrappers and containers. Atlantic also manufactures a line of high melting point or microcrystalline waxes in another M.E.K. plant completed at the Philadelphia refinery in 1948.

In the new M.E.K. plant special wax distillates are mixed with a solvent and chilled to about 10 deg F in power-driven scraper exchangers and chillers where the wax is crystallized out. This cold wax-oil-solvent mix then is fed to a battery of rotary vacuum filters where the liquid is drawn through canvas-covered drums and the wax slurry is retained on the canvas.

The wax on the drum is washed with additional solvent and continuously removed. The oil-solvent mix that is drawn through the filter is stripped in the solvent recovery section and the oil is sent to paraffin oil finishing or to cracking. The wax slurry goes through repulping and refractionating operations for further removal of oil and any other undesirable components still remaining.

In the final step known as finishing, the wax is subjected to acid treatment and filtering through beds of diatomaceous clay to produce a fully refined wax. Special blending can be performed subsequently to meet specific end-use requirements.

Automatic Tank Gaging for Inventory Control

Unique system speeds data collection and accuracy; can be adapted for remote operation of other control equipment and transmission of additional analog information

Marlin P. Nelson,
Sun Oil Company, Marcus Hook, Pennsylvania

SUN OIL COMPANY in 1953 investigated automatic tank gaging for the Marcus Hook refinery. Company engineers attacked the problem on a broad basis and investigated many alternative methods. Capacitance probes, acoustical gages, pressure gages, and floats were some of the means that were evaluated. Finally, a power-operated float and system for transmitting the tank level by digital code was developed.

This system seemed to have the characteristics demanded for refinery application. The power-operated float assured positive action for each reading so there was no doubt that the reading was accurate in spite of friction of pulleys, holdup of the float, or changes of the float position from changing specific gravity of the liquid.

Transmission of the liquid level information by binary code assured more accurate and reliable information at the remote control center. In 1955, this tank gage principle was licensed to Texas Instruments, Inc., who did further development work toward a commercial tank gaging system. In 1957, a prototype model was installed in refinery tankage together with another commercial tank gage for evaluation.

Installation on big scale. In April, 1958, installation was begun on a large-scale basis in the Lube Oil and Wax Storage Area in the Marcus Hook refinery. The main area contains seventy 10,000 and 15,000 bbl tanks of specification material available for shipment or blending. Intermediate tankage between the processing units and the main area containing nineteen 1500 and 5000 bbl tanks were also equipped with automatic gages to read out at the one control center in the main area. This intermediate tankage was about ¼ mile away from the control center.

Better accuracy. Accuracy of inventory data is improved by the elimination of 15 chances for human error in transcribing data and calculation of each tank inventory. Inventory information can be obtained faster and more frequently for management's use in the control of losses and plant production. Our goal is to provide a complete refinery inventory within two hours of the closing gage time.

Another important consideration is the flexibility that the tank gaging system has for gathering other analog information and the remote operation of valves and pumps. These features will be superimposed on the system as the refinery progresses in its modernization and automation program. Installation of a similar system is already underway for all crude, gasoline, distillate, and fuel oil tankage.

Information System

The remote control system for the Lube Oil and Wax Storage Area was equipped for 1000 information points. A particular point was selected by three-digit dialing on a standard telephone dial. Tanks in this area had not been numbered consecutively; therefore, the three-digit system permitted dialing of the old tank number to obtain the level and temperature of that tank. The 1000-point system left excess capacity for later addition of valve and motor controls or analog information, such as, pressures and capacitance probes. A schematic wiring diagram is

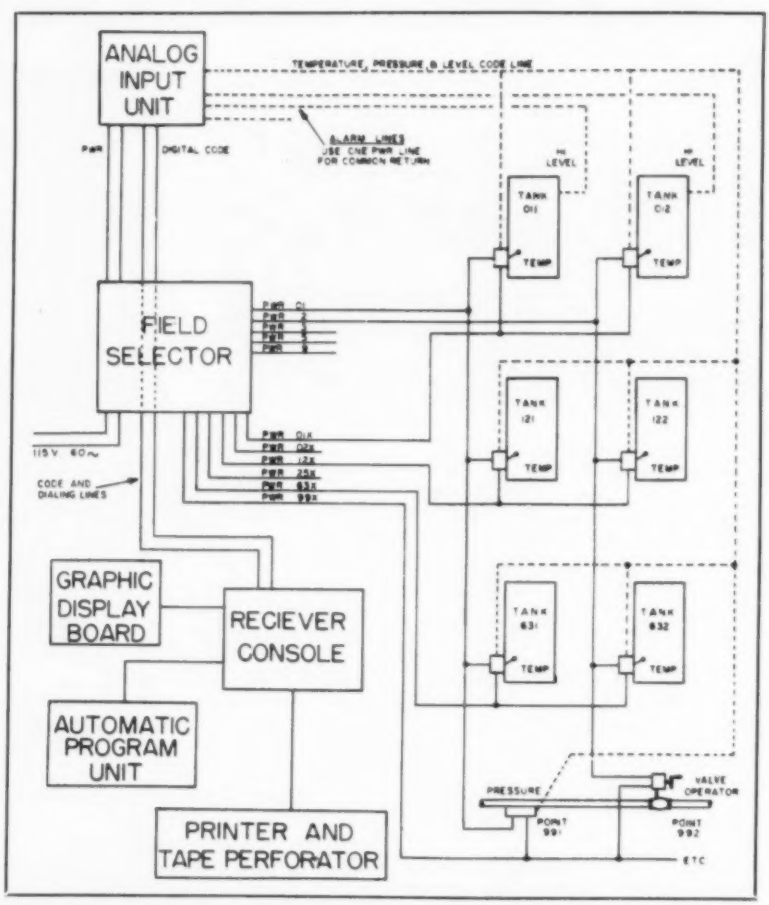

FIG. 1. **Typical installation wiring diagram** for supervisory control plus liquid level, temperature, pressure meter measurement, etc.

Presented at the Second ISA Symposium on Progress & Trends in Chemical and Petroleum Instrumentation, April 6-7, 1959, St. Louis, Missouri.

shown in Fig. 1. Upon dialing, the first two digits select a hundred-ten's wire; the third digit selects a unit's wire to complete the circuit to one and only one particular tank.

A matrix of these wires can be installed in the tank area so that minimum wiring and conduit is used. An additional circuit is required for transmitting the level information by digital code. The number of information points will be equal to the number of unit's wires times the number of hundred-ten's wires, thus a matrix 10 x 10 would provide 100 information points. By use of relays, temperature for a particular tank is obtained at the same time as level on a separate circuit. The entire system operates on 110 volt a-c.

Punch-card tie-in. The receiver console can be located remotely and connected to the field selector in the tank area by two wires or leased telephone wires. When a tank number is dialed, the liquid level and temperature are displayed visually on a receiver console. Concurrently, a printed record is made showing time, tank number, level, and temperature. At present, this printed record serves as a source of information for the daily inventory calculations. The information is put on the punched card by a key punch operator. Level and temperature information is converted to barrel inventories by a computer which has strapping information for each of the tanks. Ultimately, the level and temperature information will be punched directly on paper tape. Use of a tape to card converter will eliminate the key punch operation.

Past refinery practice required the use of elaborate gage tables for each individual tank for inventory purposes. These tables made small corrections for variations in tank diameter and equipment such as heating coils which may be inside the tank. A detailed study of each gage table revealed that the error introduced by the use of a single barrel per foot factor was often negligible. At the most, the use of one additional correction would nearly eliminate the error and simplify putting the strapping information into the computer memory.

Liquid Level Gage

The liquid level gage consists of a float connected by perforated stainless steel tape through a pulley arrangement to a gage housing mounted on the outside shell of the tank. The perforated tape engages a sprocket on a shaft which is mechanically linked to ground level reading and to the electronic side of the housing for power operation of the float. A typical installation is shown in Fig. 2.

Local reading then depends on the response to a free-riding float. However, remote reading for inventory purposes depends on power operation of the float. Upon interrogation from the remote center, a motor in the gage housing engages the shaft and starts raising the float in the liquid. The change of force at the moment the float leaves the liquid surface, similar to raising an inverted tumbler from a pan of water, trips the digital code system for transmission of the level in feet, inches, and 1/16 in. to the remote control center. This remote reading is not affected by the effect of the liquid specific gravity through change of product or temperature on the buoyancy of the float. The true liquid surface is read at all times.

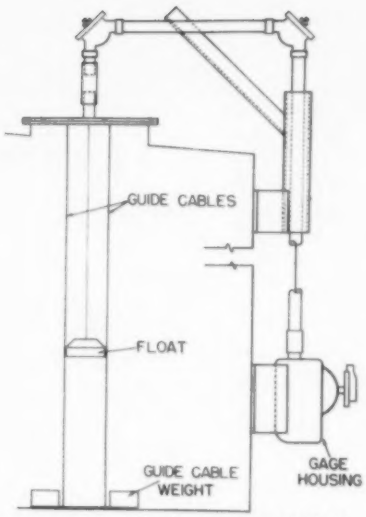

FIG. 2. **Typical liquid level gage installation.** Perforated tape engages sprocket on a shaft which is mechanically linked to ground level reading and to electronic side of the housing for power operation of the float.

Floating roof gages. Hand gaging of floating roof tanks had required two pieces of information: (1) Height of liquid in the tank, and (2) immersion of the floating roof in the liquid. A system to get accurate inventory with one reading was desired. It was observed that the floating roof immersion varied about 1 in. in gasoline service. A drum with 6 in. of transformer oil was placed on top of the floating roof in which the float operated.

The reading could be calibrated directly for the height of liquid up to the undersurface of the floating roof. Now, the volume of oil in the annular space between the floating roof and the shell of a 90 ft diameter tank is only 4.5 bbl per in. By comparison, 1/16 in. on the full diameter of the tank represented 7.6 bbl. For our purpose, a variation of 1 in. in immersion could be neglected on this basis. However, it could not be neglected if the float had been placed directly in the tank product through a well in the floating roof. For the same liquid height, the true tank inventory would be in error 121 bbl for a 1 in. change in floating roof immersion.

Roof angle correction. This method is easily extended to take care of tilting of floating roofs with the use of three drums. The drums are mounted 120 deg apart near the circumference of the roof and interconnected with ¾ in. pipe. The liquid level float is mounted in one of the drums and connected to the gage housing in the same way as cone roof tanks. This self-averaging device takes care of any change in angle of the floating roof.

Accuracy checks. Automatic gaging not only eliminates labor in a routine task but, perhaps more important, improves the accuracy of inventory data. A statistical study was attempted to determine the reproducibility of readings with automatic gaging. All that could be determined was that the reproducibility was equal to or less than plus or minus 1/16 in., the smallest division recorded by the equipment. A comparison with other statistical studies is:

Automatic gage	±1/16″
Accounting type hand gage	±4/16″*
Routine type hand gage	±5/16″*

. . . . . (1)

*95% probability limits

A review of refinery routine gaging indicates that routine hand gaging under all weather conditions may be even poorer than indicated.

Sensing level data. The liquid level information is transmitted from the gage housing to the remote control center in a binary decimal code. The gage housing consists of two sections: the mechanical section which was described previously; and, the electronic section which transmits the information.

The shaft transmits motion of the float from the mechanical section to a base film which is printed with a binary code for the liquid level in 1/16 in. increments. Two columns of transparent windows on this film form the bits of digital information. The film is scanned by a pair of photocells as power is applied to raise the float. The point on the tape is sensed instantly as the float leaves the surface. The level information which is printed in code on the film is transmitted on two code wires to the console at the control center. The windows or bits of information are 1/16-in. apart which permit reading the liquid level to that fraction of an inch.

Temperature Measurement

For inventory purposes, all volume measurements must be corrected to the standard temperature of 60 F. Accurate measurement of the average tank tem-

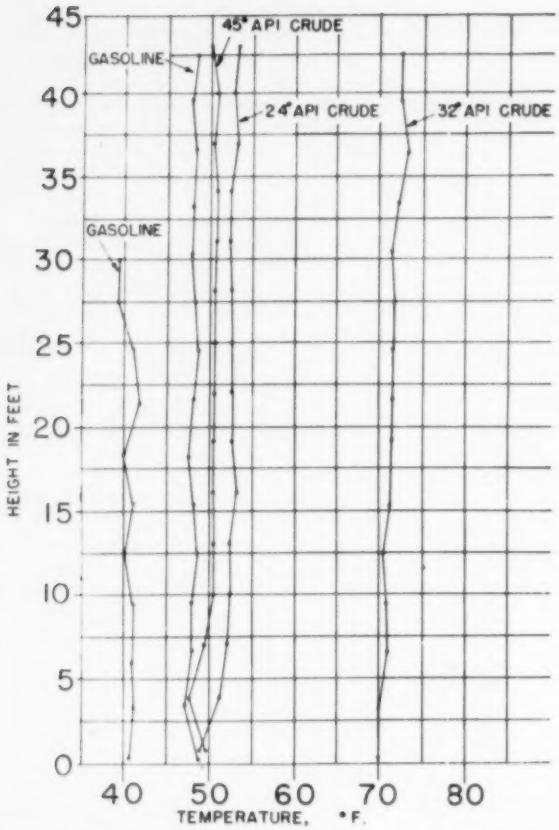

FIG. 3. **Temperature profiles** for crude oil and gasoline show variations of 3 F or less.

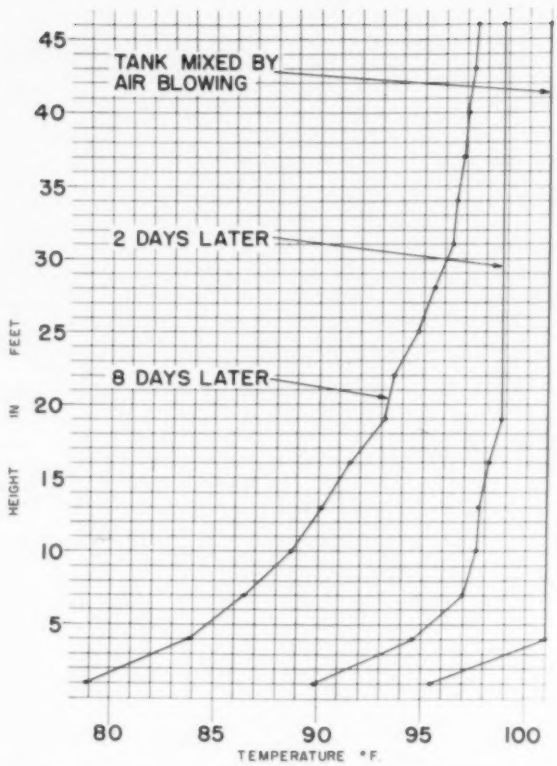

FIG. 4. **Temperature gradients** for 15,000-bbl tank of 2000 Saybolt seconds viscosity lube oil, July 1958. Mixing eliminates gradients which do appear a few days later.

perature is required since an error of 2.5 F gives an error of 0.1 percent in the inventory corrected to 60 F. Temperature gradients were measured by thermocouples in a number of tanks with a variety of products to determine where and how to obtain an average tank temperature. Typical temperature profiles for crude and gasoline in Fig. 3 show temperature variations of 3 F or less. These profiles were taken about 2 ft from the shell in tanks of 55,000 and 80,000-bbl capacity. Profiles taken in the center of the same tanks were nearly identical. In this case, a point temperature 3 ft from the shell and 3 ft above the tank floor gave the desired accuracy at minimum cost for equipment.

Gradients in viscous products. Appreciable temperature gradients do occur in more viscous products. Typical temperature profiles for a lube oil of 2000 Saybolt seconds viscosity at 100 F in a 15,000 bbl tank is shown in Fig. 4. This chart shows that it was possible to mix the tank by air blowing so that the temperature gradients were virtually eliminated. However, the gradient quickly appeared again. The tank was 48 ft in diameter by 48 ft high. The temperature difference between the top and bottom was sometimes 30 F. A locally-mounted dial thermometer which was 5 ft above the tank floor gave readings as much as 16 F lower than the average tank temperature. In this case, the use of a spot temperature would give an inventory in error by 0.6 percent or 90 bbl of a relatively valuable product. No appreciable horizontal gradients were observed although a 1060 sq ft fintube heater was located on one side of the tank.

Temperature averaging. Some type of averaging temperature device was obviously required for the more viscous products. While the data presented showed no horizontal gradients, other information indicated horizontal variations might occur with certain heating coil arrangements. On this basis, a boom was installed which fastened and pivoted at one end on the bottom of the tank. The boom was buoyant so that the other end was free to rise and fall with the liquid level. A resistance element was mounted along the 40 ft length of the boom as the primary sensing element.

Temperature measurements made concurrently with the liquid level measurements are stored in the analog input unit until required at the receiver console. The analog input unit is a self-balancing decade potentiometer which converts analog information to the standard 16-bit binary coded decimal signal. The analog input unit can be equipped with four or more scale factors so that information on pressures, capacitance, voltages, or other analog information can be transmitted and received over the same system.

Other installations considered. The reliability and application of automatic tank gaging on a large scale has proved satisfactory. Since this was the first major installation of this type, some minor design changes were made to improve reliability to a high degree. Installation of similar systems in other areas are under study and expected to near completion by the end of the year. Now more accurate information is available sooner for management decisions.

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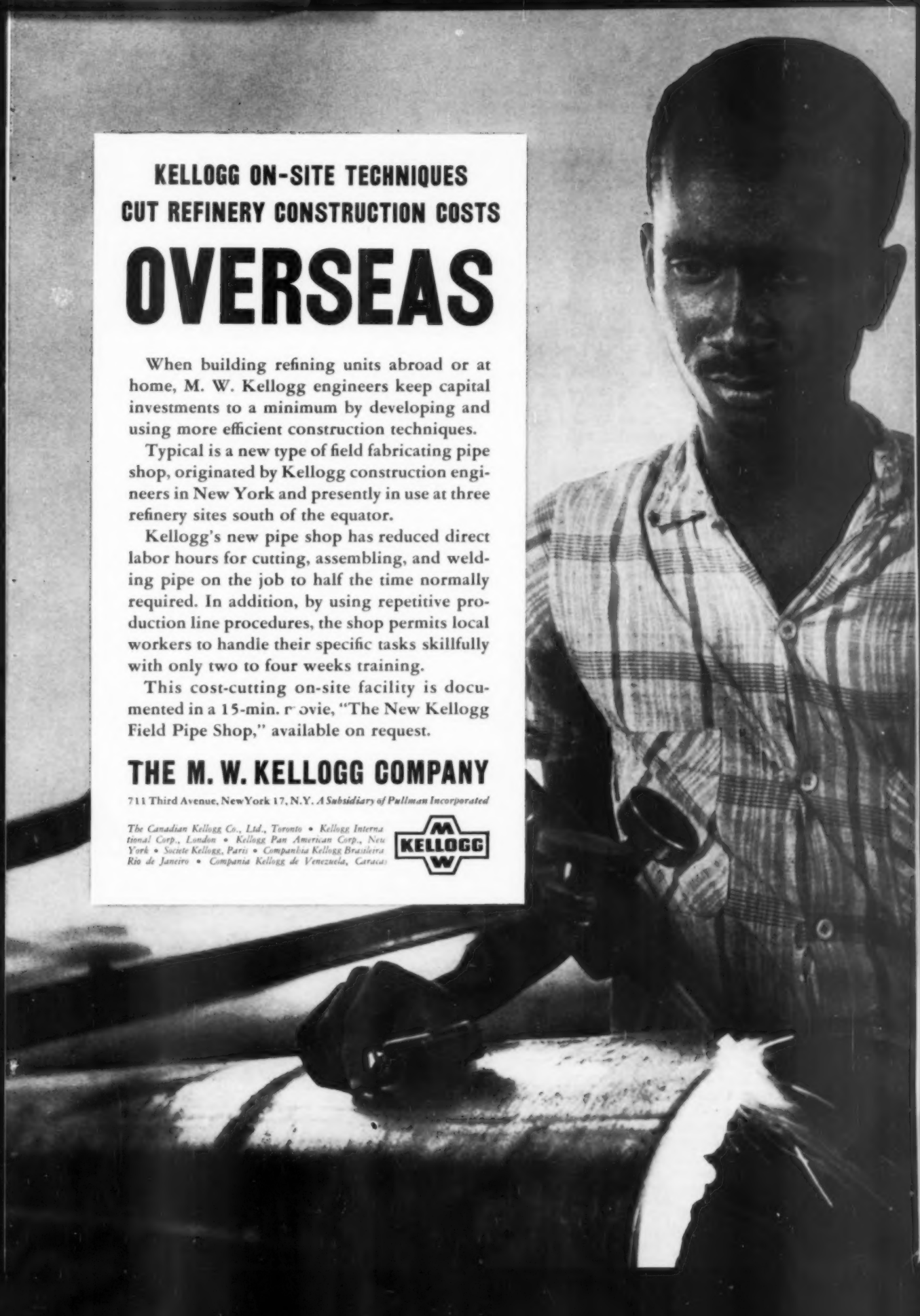

KELLOGG ON-SITE TECHNIQUES CUT REFINERY CONSTRUCTION COSTS

OVERSEAS

When building refining units abroad or at home, M. W. Kellogg engineers keep capital investments to a minimum by developing and using more efficient construction techniques.

Typical is a new type of field fabricating pipe shop, originated by Kellogg construction engineers in New York and presently in use at three refinery sites south of the equator.

Kellogg's new pipe shop has reduced direct labor hours for cutting, assembling, and welding pipe on the job to half the time normally required. In addition, by using repetitive production line procedures, the shop permits local workers to handle their specific tasks skillfully with only two to four weeks training.

This cost-cutting on-site facility is documented in a 15-min. movie, "The New Kellogg Field Pipe Shop," available on request.

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M KELLOGG W

To Upgrade C_5/C_6 Naphthas . . .

A New Isomerization Process

A highly active catalyst permits low temperature, liquid phase operation

K. P. Lanneau • W. F. Arey
Esso Standard Oil Company
Baton Rouge, Louisiana

S. F. Perry • A. Schriesheim
Esso Research & Engineering Company
Linden, New Jersey

H. A. Holcomb
Humble Oil and Refining Company
Baytown, Texas

There is a continuing upward trend in octane requirements of motor gasoline. This trend, unless overcome by advances in refining technology, will be accompanied by increased manufacturing costs. The large amount of low octane light virgin naphtha presently going into motor gasoline pools makes incremental improvement of pool octane increasingly difficult. As octane levels continue to rise, refiners will have need for an economical process to upgrade this fraction of crude oil. Fig. 1 shows approximate octane levels of major components in a projected 1960 gasoline pool for a typical United States (Gulf Coast location) refinery.[1] It is seen that the C_5/C_6 virgin naphtha, which comprises 15 to 20 volume percent of the pool, is by far the lowest octane component. This tends to place a ceiling on pool octane. Furthermore, with low octane in a major low-boiling gasoline component, it is becoming increasingly difficult to produce premium grade gasolines of required volatility and road octane performance. This is especially true in refineries maximizing middle distillate and fuel oil yields, where catalytic cracking is not employed.

The major components in light virgin naphthas are shown in Fig. 2. There is a predominance of low octane paraffins (Table 1) — n-pentane, n-hexane, and methyl pentanes. The Louisiana C_5/C_6 is a relatively good light virgin naphtha, while the Arabian is a typical low octane C_5/C_6 virgin naphtha. These stocks are hereinafter discussed in detail and their complete composition and octane ratings are in Tables 3 and 4.

Why Isomerization Is Attractive

In theory, there are three ways to improve the octane rating of light virgin naphtha—by **isomerization,** by **dehydrogenation** to olefins, and by **aromatization.** Aromatization, of course, is restricted to C_6 or heavier. The C_5 and C_6 isoparaffins, produced by isomerization, have high octane numbers by both the ASTM Research and Motor methods, and excellent lead response, as shown in Table 1. Most light olefins have high Research octane ratings, but their Motor method octanes and lead susceptibility are poor. Therefore, olefins are not considered premium components for future high octane gasolines. Both dehydrogenation and aromatization have the further disadvantage that they appear to be inherently less selective reactions, giving considerably lower yields of liquid product. The isomerization reaction is outstanding in this respect; theoretical volumetric yields are about 100 percent and can be closely approached in practice.

Importance of Reaction Temperature

The attractiveness of a C_5/C_6 isomerization process is critically dependent upon obtaining high conversion to the most branched isomers. High conversion means high octane improvement per pass and the reduction or elimination of costly product recycle. Conversion in isomerization is limited by the thermodynamic equilibrium, which is much more favorable for branched paraffins at lower temperatures. This is particularly true with respect to the concentration of 2,2-dimethyl butane in the C_6 paraffins. Table 2 shows experimentally observed equilibrium concentrations for C_5 and C_6 paraffins and C_6 naphthenes at three temperature levels. Fig. 3 shows the important effect of reaction temperature on maximum product octane attainable in isomerization of C_5 and C_6 paraffins without recycle. The estimated octane levels in Fig. 3 are based on the equilibrium (Table 2) of the C_5 and C_6 paraffins. Unless otherwise indicated all octane numbers reported in this paper are ASTM values. Octane numbers above 100 are on the Coordinating Research Council scale.

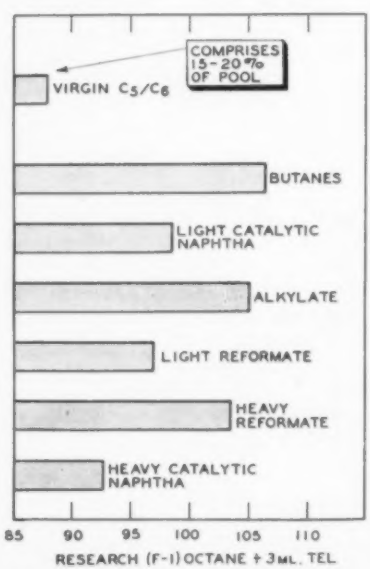


FIG. 1. Major components in a 1960 motor gasoline pool.

The high-temperature level for C_5/C_6 isomerization, 700 to 900 F, is the approximate range of several recently developed "Hydroisomerization" vapor phase processes,[3,4,5] which use supported precious metal catalysts. The 200 to 250 F temperature range is typical of the so-called "$AlCl_3$-Sludge" process,[2] in which a C_5/C_6 feed is isomerized in the liquid phase in the presence of an $AlCl_3$-hydrocarbon complex as the catalyst. The 80 to 120 F temperature range for isomerization is representative of the process.

Fig. 3 shows that the process has a potential advantage in once-through product octane, over the hydroisomerization type processes, of more than 5 octanes in the C_5 paraffins and 9 octanes in the C_6 paraffins. On the other hand, equilibrium C_6 naphthenes have higher octane at the higher temperature. However, since typical refinery C_6 fractions contain no more than 10 to 20 volume percent naphthenes, the effect of paraffins predominates. In

Adapted from a paper presented by the authors to the Fifth World Petroleum Congress, New York, June 1959.

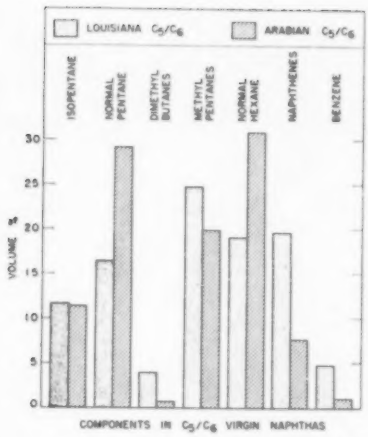


FIG. 2. Major components in typical light virgin naphthas.

TABLE I
OCTANE NUMBERS AND BOILING POINTS OF C_5/C_6 HYDROCARBONS
(FROM API PROJECT 45)

Component	Boiling Point °F.	ASTM OCTANE NUMBER RESEARCH (F-1) Clear	RESEARCH (F-1) + 3 ml. TEL	MOTOR (F-2) Clear	MOTOR (F-2) + 3 ml. Tel
C_5 Paraffins					
Isopentane	82	92.3	108.7	90.3	—
***n*-Pentane**	97	61.7	88.7	61.9	85.6
C_6 Paraffins					
2,2-Dimethyl Butane	122	91.8	106.1	93.4	113.2
2,3-Dimethyl Butane	137	103.4	—	94.3	112.1
2-Methyl Pentane	146	73.4	93.1	73.5	91.1
3-Methyl Pentane	140	74.5	93.4	74.3	91.3
***n*-Hexane**	156	24.8	65.3	26.0	65.2
C_5 Naphthenes					
Cyclopentane	121	102.5	—	85.0	95.2
C_6 Naphthenes					
Methylcyclopentane	161	91.3	105.2	80.0	93.0
Cyclohexane	178	83.0	97.4	77.2	87.3
C_6 Aromatics					
Benzene	176	105.8	105.2	102.6	106.5
C_5 Olefins					
1-Pentene	85.9	90.9	98.6	77.1	82.9
2-Methyl 1-Butene	88.0	102.5	103.4	81.9	84.2
C_6 Olefins (Typical)					
3,3-Dimethyl 1-Butene	106	111.9	—	93.3	—
2,3-Dimethyl 1-Butene	163	101.3	103.4	82.8	85.5
1-Hexene	146.2	76.4	91.7	63.4	76.3
2-Hexene (*Trans.*)	154.2	92.7	98.4	80.8	83.2

pentane isomerization, recycle of unconverted n-pentane is feasible by fractionation of the product. Higher conversion per pass through the reaction zone does, however, reduce the cost of octane improvement of the pentane fraction.[4] In the case of C_6 fractions the boiling points of some of the paraffin isomers are very close to each other, (Table 1). The attendant high cost of super-fractionation required to separate the low octane isomers militates against product recycle in hexane isomerization. The increasing need for an economical process to upgrade the C_5 and C_6 fractions of light virgin naphtha indicates the desirability of a truly high conversion isomerization process. The new process discussed in this paper gives high conversions to isoparaffins and makes it possible to upgrade C_5/C_6 feeds to attractive octane levels without product separation and recycle.

Pilot Plant Results

Extensive pilot plant studies have been conducted during development of the process. In typical operations a combined C_5/C_6 naphtha feed is first pretreated to remove impurities which might result in poor operability or excessive catalyst consumption. The feed is then isomerized in the liquid phase at the very low temperature of 80 to 120 F, made possible by the use of an extremely active catalyst.

As discussed above the favorable thermodynamic equilibrium existing at the low reaction temperature permits high once-through conversion. A general picture of the kinetics of the process is shown in Fig. 4. The curves showing paraffin isomer distribution as a function of reciprocal space velocity (reactor holding time) are based on pilot plant data obtained on the Louisiana C_5/C_6 naphtha feed. For both the C_5 and C_6 paraffins the isomerization is a first order reversible reaction with respect to disappearance of the normal isomer. As equilibrium is approached it is seen that the effect of the reverse isomerization reactions becomes appreciable. This is indicated in Fig. 4 by the break in the scale of the abscissa (reciprocal space velocity) at a point where about 92 percent of the hexane exists as branched isomers.

At this hexane conversion level, for the Louisiana combined C_5/C_6 feed, 80 to 85 percent of the C_5 fraction exists as isopentane. Although the reaction rate for n-hexane is considerably higher than that for n-pentane, it is possible to isomerize the C_5 and C_6 fractions as a combined feed to high conversion levels on both fractions. The catalyst of the process is both active and selective at the low temperature employed. Cracking and disproportionation, which tend to occur at high conversion levels in hexane isomerization, are minimized.

Fig. 4 also shows the high concen-

TABLE II
EFFECT OF TEMPERATURE ON ISOMERIZATION EQUILIBRIA

	New Esso Process	$AlCl_3$ Sludge Processes	Hydroisomerization Processes
TEMPERATURE LEVEL—°F.	80-120	200-250	700-900
EQUILIBRIUM COMPOSITION* (Volume %)			
C_5 Paraffins			
Isopentane	90	85	62
n-Pentane	10	15	38
C_6 Paraffins			
2,2-Dimethyl Butane	52	39	10
2,3-Dimethyl Butane	10	10	8
2-Methyl Pentane	23	28	37
3 Methyl Pentane	9	13	20
n-Hexane	6	10	25
C_6 Naphthenes			
Methylcyclopentane	15	35	87
Cyclohexane	85	65	13

* Approximate values, based on selected experimental data rather than thermodynamic calculations. References: [4, 6, 7, 8, 9, 10].

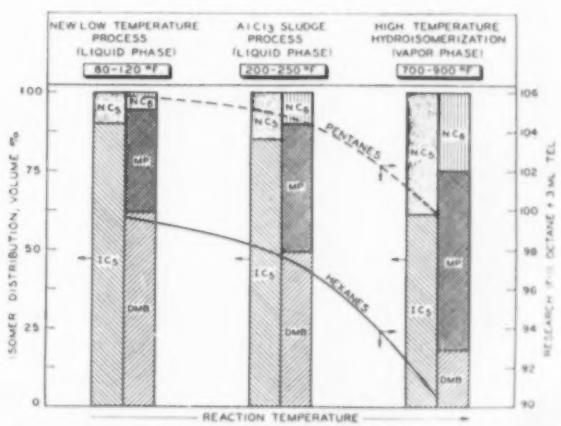
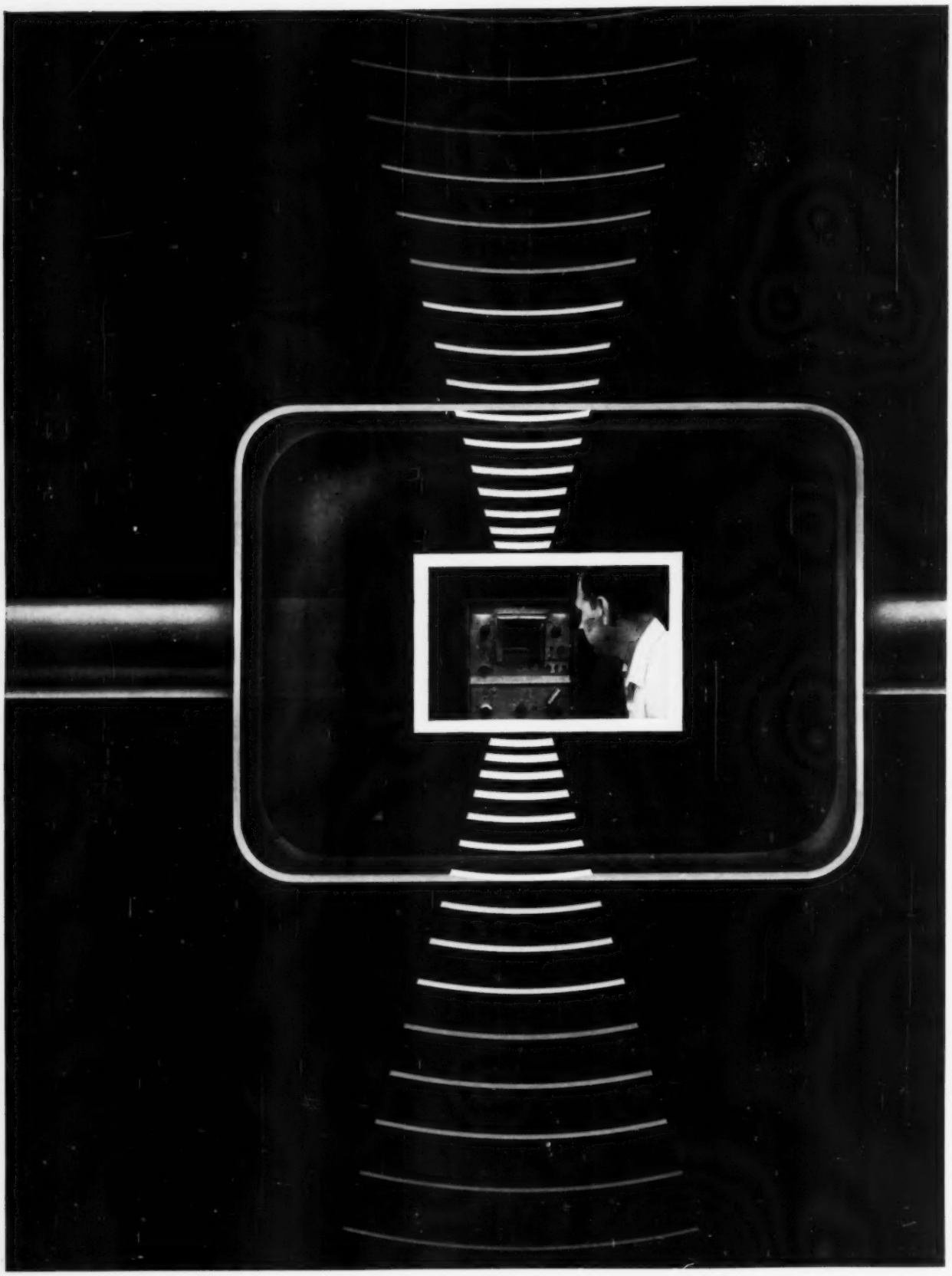


FIG. 3. Effect of isomerization temperature on equilibrium composition (from Table 2) and octane of C_5 and C_6 paraffins.



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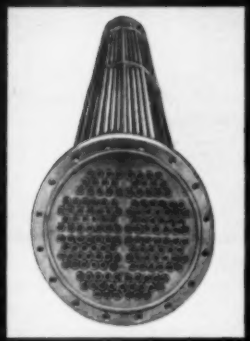

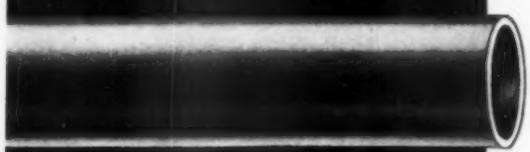

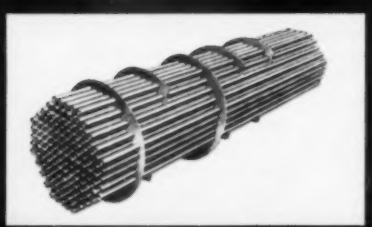

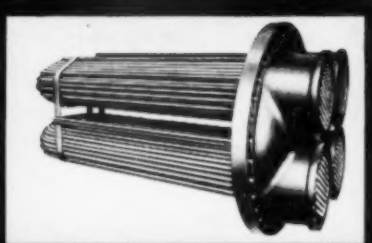

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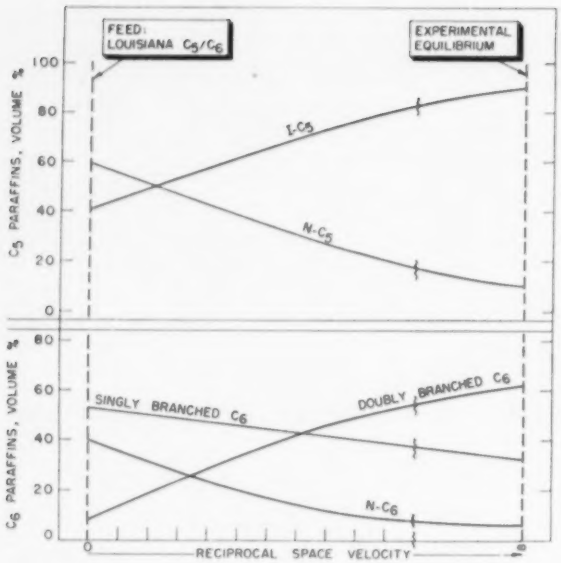

FIG. 4. Effect of isomerization severity on isomer distribution of C_5/C_6 paraffins (reaction temperature = 80 to 120 F).

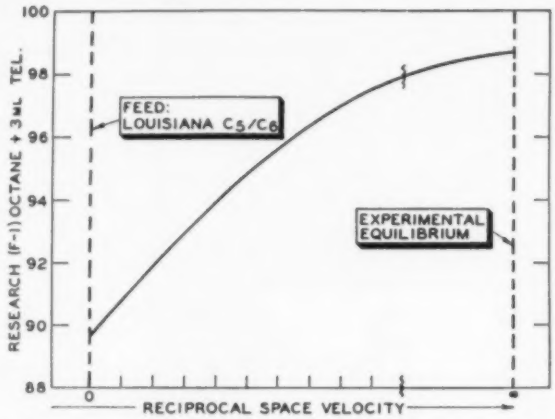

FIG. 5. Effect of isomerization severity on product octane (reaction temperature = 80 to 120 F).

tration of doubly branched C_6 isomers (2,2- and 2,3-dimethyl butane) produced at high n-hexane conversion levels. This contributes substantially to the octane rating of the C_5/C_6 isomerizate. The effect of isomerization severity, again expressed as reciprocal space velocity, on octane of the isomerizate from Louisiana C_5/C_6 is seen in Fig. 5, which complements Fig. 4. Above 98 octane (Research + 3 ml. TEL per U. S. gal) which corresponds to 92 percent C_6 branched isomers in Fig. 4, it is increasingly difficult to upgrade the naphtha further as equilibrium is approached.

Typical feed and product data from pilot plant operations isomerizing the virgin Louisiana C_5/C_6 feed are presented in detail in Table 3. This feed is a good quality light virgin naphtha, having a relatively high Research (+ 3 ml. TEL) octane rating of 89.5. Even so, isomerization of this feed upgraded it approximately 8.5 octane numbers to a 98.0 level.

Table 4 shows similar data for isomerizing the C_5/C_6 fraction from an Arabian crude. This feed contains less benzene and naphthenes and substantially more n-pentane and n-hexane than the Louisiana C_5/C_6. Thus, it is a lower octane feed. Since isomerizate octane number is limited by equilibrium considerations, the product from the Arabian feed has an octane number about equivalent to the product from the higher quality Louisiana feed. Therefore, the low temperature once-through isomerization process upgrades the Arabian feed by a very substantial 14.5 Research octane numbers.

C_5/C_6 Isomerizate as a Motor Gasoline Component

The data in Tables 3 and 4 show that high conversion isomerization by the Esso low-temperature process can upgrade C_5/C_6 virgin naphthas to a Research octane level approximately equivalent to that of other major components in motor gasoline pools. Fig. 6 points up further the excellent quality of the C_5/C_6 isomerizate. The isomerizate has a very high Motor octane rating. For instance, at a level of 98 Research + 3 ml. TEL, the rating by the Motor method is 100 octane with 3 ml. TEL per gal. The high concentration of branched paraffins in the isomerizate gives this material a decided advantage in lead susceptibility and Motor octane rating over typical catalytic reformates, which are rich in aromatic hydro-

TABLE III
LOUISIANA C_5/C_6 FEED AND PRODUCT COMPOSITION, VAPOR PRESSURE, AND OCTANE RATINGS

Component	Feed Volume %	Product* Volume %
Normal Pentane	16.3	4.8
Isopentane	11.6	23.1
Normal Hexane	19.0	4.4
2,2-Dimethyl Butane	1.9	20.7
2,3-Dimethyl Butane	2.1	5.0
2-Methyl Pentane	15.3	11.4
3-Methyl Pentane	9.4	6.2
Cyclopentane	2.3	1.8
Methylcyclopentane	10.9	2.2
Cyclohexane	6.4	15.6
Benzene	4.8	4.8
Normalized Total	100.0	100.0
Reid Vapor Pressure, Psig.	9.2	11.1
ASTM Octane Ratings		
Research (F-1) + 3 ml. TEL	89.5	98.0
Motor (F-2) + 3 ml. TEL	86.6	101.0

* Converted once-through at 80-120°F. C_5/C_6 yield is greater than 99 Vol. %

TABLE IV
ARABIAN C_5/C_6 FEED AND PRODUCT COMPOSITION, VAPOR PRESSURE, AND OCTANE RATINGS

Components	Feed Volume %	Product* Volume %
Normal Pentane	29.1	7.1
Isopentane	11.3	33.3
Normal Hexane	30.4	4.1
2,2-Dimethyl Butane	0.0	25.2
2,3-Dimethyl Butane	0.7	4.6
2-Methyl Pentane	11.3	12.0
3-Methyl Pentane	8.6	5.1
Cyclopentane	0.7	0.1
Methylcyclopentane	5.4	0.9
Cyclohexane	1.5	6.6
Benzene	1.0	1.0
Normalized Totals	100.0	100.0
Reid Vapor Pressure, Psig.	10.0	12.6
Octane Ratings		
Research (F-1) + 3 ml. TEL	84.0	98.5
Motor (F-2) + 3 ml. TEL	83.9	101.5

* Converted once-through at 80-120°F. C_5/C_6 yield is greater than 99 Volume %.

carbons. The increasing importance of Motor octane in producing gasolines for modern automobiles should make the low-temperature isomerization process especially attractive.

While C_5/C_6 isomerization may soon be needed in many refineries as a pool octane improvement step, use of the process to produce a high octane blending component is especially interesting. Even in cases where a refiner can manufacture enough octanes to meet pool requirements, it may be very difficult to separate the high octane streams required to produce a premium grade gasoline some 7 to 9 octane numbers higher than the regular grade. Volatility specifications may also pose a problem in high octane gasoline blending. Thus, high octane ratings and inherent volatility of C_5/C_6 isomerizate make it an excellent blending component for premium gasoline production.

Fig. 7 shows the Research octane blending characteristics of low-temperature C_5/C_6 isomerizate when it is blended into a very high octane pool rich in aromatics. This is a typical future pool for premium gasoline. While the straight rating on the isomerizate is 98 octane on a Research basis, it blends into the pool as if it had a 103 to 104 Research rating. This is referred to as the blending octane value.* The isomerizate blends at a value near the level of the high octane pool. It is only slightly inferior to a butylene alkylate.

The C_5/C_6 virgin naphtha, from which the isomerizate was produced, is too low in octane to be considered for blending into future premium gasolines. Therefore, its blending value in a lower octane pool for future regular grade gasoline is given in Fig. 7. The difference between the blending octane values shown for the virgin naphtha and the isomerizate is 11 to 12 numbers, and this represents the amount by which the isomerization process upgrades the Louisiana C_5/C_6 fraction as a gasoline blending component.

Fig. 8 shows the important Motor octane blending characteristics of the same isomerized C_5/C_6 naphtha. Although the isomerizate has a Motor octane blending value lower than its straight rating, it blends at a level well above that of the high octane pool. In other words, the isomerizate would improve the Motor octane rating of the future premium grade gasoline pool. In this respect it is approximately equivalent to the butylene alkylate. Fig. 8 also shows that low-temperature isomerization would appreciate the blending value of the Louisiana C_5/C_6 naphtha by 11 octane numbers on a Motor method basis.

* Octane blending values in Fig. 7 and 8 were determined on blends containing 25 volume percent of the component and 75 percent of the pool indicated.

C_5/C_6 Isomerizate for Aviation Gasoline

While the major need for isomerization is to upgrade light virgin naphtha in motor gasoline pools, C_5/C_6 isomerizate is a potential aviation gasoline blending component. Table 5 shows the aviation anti-knock ratings of a low-temperature isomerizate compared to ratings of a high grade alkylate and a light virgin naphtha, which are typically the best and poorest components, respectively, in aviation pools. The relatively high lean and rich ratings of the C_5/C_6 isomerizate would make it possible to back out some of the light virgin naphtha base and to blend some of this better component into aviation gasoline, thus reducing the requirement for high octane alkylate. This would have the effect of extending the supply of aviation gasoline, or of making more high octane alkylate available for use in premium grade motor gasolines. Blending studies have shown that up to 20 volume percent of low-temperature C_5/C_6 isomerizate can be included in an aviation pool to produce a high grade 115/145 (lean/rich) gasoline of required volatility and vapor pressure.

Process Economics

Estimates of the process investment and direct operating costs for low-temperature C_5/C_6 isomerization plants of two sizes are given in Table 6. These costs include feed preparation to remove certain impurities, present in most feeds, which might result in poor operability or excessive catalyst consumption. It is assumed that a feed of suitable boiling range is available. Therefore, no feed fractionation costs are included. Direct operating costs include operating labor, catalyst and chemicals, utilities and maintenance.

The process investments shown in Table 6 are approximate values and would, of course, vary considerably with engineering standards and location. It should be noted again that the Esso low-temperature process makes a high octane product with once-through isomerization. This eliminates the high investment and operating costs of superfractionation for recycle required in higher temperature processes to reach a comparable octane level.

Unit costs for octane improvement (cent per octane barrel) are affected by such factors as plant size and feed quality. Since product octane number is limited by equilibrium at the temperature employed, lower unit costs for a given processing cost can be obtained with low octane feed stocks, such as the Arabian C_5/C_6. It has been assumed that a total of C_5/C_6 virgin

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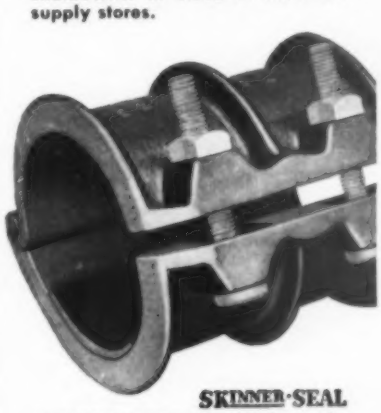

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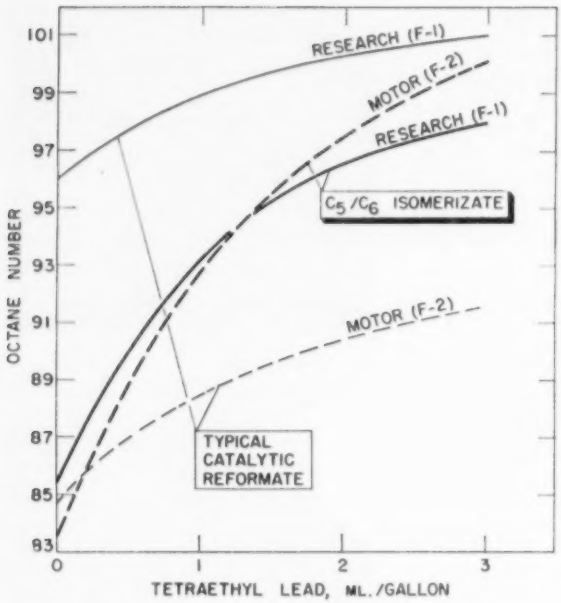

♦ FIG. 6. C_5/C_6 isomerizate compared to catalytic reformate on ASTM octane ratings. (Isomerizate from Louisiana Virgin C_5/C_6.)

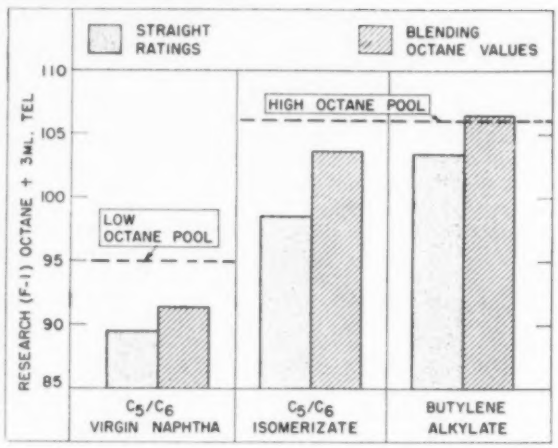

FIG. 7. Research (F-1) octane blending characteristics of light virgin naphtha, isomerizate and alkylate. Virgin naphtha and isomerizate are feed and product from isomerizing Louisiana C_5/C_6.

naphtha is fed to the isomerization process. The addition of a feed deisopentanizer would permit some further octane improvement and add flexibility for gasoline blending. This might or might not lower the unit cost of octane improvement, depending upon isopentane content of the feed. In some refineries feed stocks of very high n-paraffin content are available as a result of superfractionation and/or extraction operations. This provides favorable circumstances for economical octane improvement by isomerization.

It is estimated that total costs of octane improvement by the Esso low temperature process are generally in the range of 5 to 10 cents per octane barrel, depending upon plant size and feed quality. This includes direct costs, normal overhead charges for an average refinery, and three-year amortization of the plant. This low cost for motor gasoline octane improvement is very attractive to refiners at present and projected octane levels.

Nomenclature

MP	— Methyl Pentane
DMB	— Dimethyl Butane
B/CD	— Barrels per Calendar Day
$/BPCD	— Dollars per Barrel per Calendar Day
¢/B	— Cents per Barrel

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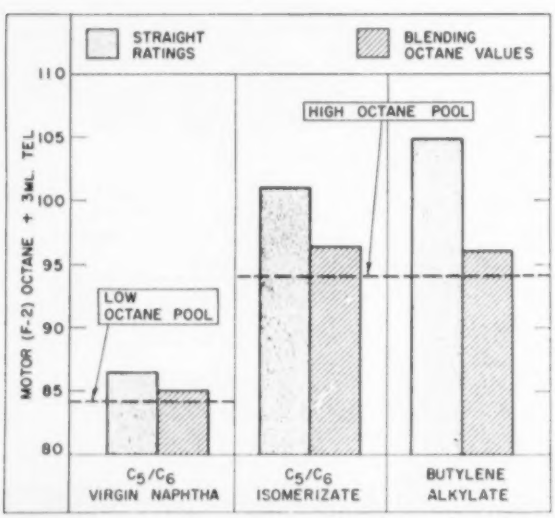

FIG. 8. Motor (F-2) octane blending characteristics of light virgin naphtha, isomerizate, and alkylate. Virgin naphtha and isomerizate are feed and product from isomerizing Louisiana C_5/C_6.

TABLE V

C_5/C_6 ISOMERIZATE COMPARED TO OTHER AVIATION GASOLINE BLENDING COMPONENTS

Component	Aviation Anti-Knock Ratings* Lean (ASTM-D614)	Supercharge Rich (ASTM-D909)
C_5/C_6 Isomerizate	109	129
Alkylate	130	163
Light Virgin Naphtha	90	97

* Ratings at 4.6 ml TEL/U.S. Gallon. Numbers above 100 are Performance Numbers, below 100 are Octane Numbers.

TABLE VI

ECONOMICS FOR ESSO LOW TEMPERATURE ISOMERIZATION PROCESS

Plant Size, B/CD	5000	17,000
Process Investment, $/BPCD	400	250
Direct Operating Costs, ¢/B	35	30

Plant Expansion on Upswing in Germany and Austria

Accent is on petrochemicals as industry girds to meet rising domestic demand. Austria is nearly self-sufficient

Dr. E. G. Nottes,
Ludwigshafen/Rhine, Germany

CONSUMPTION of petroleum products in Central and Western Europe continues upward at a faster pace than oil production in most countries. Austria is the only exception, where production is almost equal to demand. Deficiencies are largely made up by imports from the Persian Gulf area. This increase in domestic demand has brought about huge refinery expansion with attendant pipeline systems to bring the crude to processing areas.

Compared with other oil producing countries in the world, the large scale developments in Central Europe are of a somewhat more recent date. Most industries and households in Austria, the Benelux countries, Germany and Switzerland have been relying on black and brown coals besides electricity from waterpower as their main source of energy and heating. Until recently, about 80 to 90 percent of the energy requirements of Western Germany was based mainly on coal.

AUSTRIA INCREASES CAPACITIES

In 1958, construction started on the new state-owned Schwechat refinery near Vienna. It will have a capacity of 32,700 bbl per day and is scheduled to begin operations in 1960. The second stage is planned to reach 53,200 bbl per day output. Distillation, cat cracking, cat reforming and a unit for ethylene separation will be built.

In the same year Danubia Petrolchemie A.G. was organized. It started with a capital of 90 million Austrian shillings. Shares are divided by 40 percent Austrian Nitrogen Company, Linz and 40 percent Italian Montecatini Chemical Trust and 20 percent will be reserved for other capital investment. The petrochemical works are planned to be located at Schwechat near the new refinery. Polypropylene among other products will be manufactured.

TABLE 1. Production Capacity of Austrian Refineries — 1958

Government-Owned,	Location	Capacity, bbl/day
O.M.V.	Schwechat	13,500
	Lobau	8,200
	Korneuburg	7,200
	Moosbierbaum	7,400
	Vosendorf	2,900
Shell	Floridsdorf	4,700
Mobil Oil	Kagran	4,400
	Neusidl	1,090
	Kledering	400
	Lobau	——

REFINING AND PETROCHEMICALS IN GERMANY

Refinery throughput has been increased remarkably in the last years in the federal republic of Germany. See Table 2.

TABLE 2. Total Refinery Capacity for Germany, bbl/day.

1956	238,000	1958	310,000
1957	246,000	1959*	614,000

*Estimated

It is expected to go up in the future. Estimates foresee an expansion of refinery capacity to almost 820,000 bbl per day in 1962.

In view of the establishment of the European common market it will not be easy to forecast how this large expansion program will tie in with planning in other European countries. However, the fact remains that the refining industry in Europe is highly competitive and every larger oil company is doing its best to win or keep a fair share of the market.

Total consumption of mineral oil products in the last few years is given in Table 3.

TABLE 3. Consumption of Mineral Oil in Germany, bbl/day.

1955	217,000	1957	340,000
1956	313,000	1958	390,000

Future estimates are presented according to Erdol U. Kohle, 1958, page 282 and in Table 4.

TABLE 4. Future German Requirements, bbl/day.

1959	450,000	1961	573,000
1960	532,000	1963	675,000

New Projects and Developments

Nearly all German refineries are in the hands of private enterprise representing German, European, and American oil companies.

British Petrol Company is constructing a new large refinery near the Ruhr area at Dinslaken. Crude supply will come through the "North West big pipeline." There will be straight run distillation, platforming capacity of about 10,200 bbl per day, gas oil desulfurization of 10,200 bbl per day will be included. Besides heating oil there will be produced also bitumen. Several 2050 bbl per day of by-products are foreseen to go into petrochemicals. The refinery is a cooperative effort with Farbwerke Bayer at Dormagen.

Caltex has come into Germany in the last few years with service stations. At the moment there is not yet a Caltex refinery in this country.

Deutsche Erdol AG. After completion and enlargement of their refinery at Heide (North Germany) with platforming and gas oil desulfurization included, DEA also is producing ethylene, propylene and pure propane as base materials for petrochemical processes.

The urea extraction of straight chain paraffinic hydrocarbons according to BASF German Patent 869,070 has been operating successfully for four years on a technical scale at Deas refinery. The company is planning to build a 41,000 bbl per day refinery at Karlsruhe on the upper Rhine provided the pipeline project Marseille (France)-Karlsruhe will go through.

Esso AG Hamburg has recently put "onstream" a large new refinery near Cologne on the Rhine. Catalytic reforming and gas oil desulfurization combined with atmospheric distillation will also give large amounts of fuel oils.

Base products for petrochemical manufacture will be delivered to Chemische Werke Huls especially for synthetic rubber production. A pipeline will transport the required amounts of products to Huls. Crude oil is coming through the new pipeline from Wilhelmshafen on the North Sea to Cologne, thus relieving the River Rhine transport systems. The refinery's capacity is rated at 71,600 bbl per day.

Daily newspapers discussed reports with regard to Esso's eventual intention to participate in the planning of the Marseille-Karlsruhe pipeline project. If so, this could mean eventually considering construction of a new Esso refinery at Karlsruhe.

Gewerkschaft Erdölraffinerie Lingen. This refinery was originally based on German crude from the nearby Emsland fields (near the Dutch border). Its capacity will be increased from less than 20,000 bbl per day to perhaps 50,000 bbl per day. Fuel oil will be one of the larger products. It is anticipated that crude oil (Mid East) will come through the Wilhelmshafen Cologne pipeline.

Gelsenberg Benzin AG in the Ruhr area is at the moment Germany's largest refinery. Their combined straight run distillation, catalytic high-pressure hydrogenation, TCC cat cracking, platforming and gas oil desulfurization program is now able to process 92,000 bbl per day of crude oil. A pipeline connects the plant with the Wesel Rhine harbor. More than 20,000 bbl per day of German crude oil is processed besides large amounts of Mid East oils.

Finished products go to BV-Aral, Esso and Caltex sales organizations. By-products are taken up by Chemische Werke Huls for petrochemicals manufacture. Chemische Werke Huls operates Germany's largest synthetic rubber plants.

Mobil Oil AG Bremen-Oslebshausen. In 1957, Mobil Oil put a new platformer into operation and is also running a cat gas oil desulfurization unit. In 1958, a new two-stage distillation unit of a total capacity of approximately 16,400 bbl per day has been put onstream in addition to already existing facilities.

In Germany, Mobil Oil AG is working together to some extent with Gelsenberg Benzin and delivers white products to BV-Aral for distribution. Lube oils are sold in Germany under Mobil Oil's own name.

Deutsche Purfina AG is a subsidiary of the Belgian Petrofina Company and is running a refinery at Muehlheim/Ruhr. The company is erecting a large new refinery at Duisburg (Ruhr area) which is scheduled to start production about 1959. It will have catalytic reforming and gas oil desulfurization units.

The refinery is based on crude oil supplied by the Wilhelmshafen-Cologne pipeline. Main product will be fuel oils for the Ruhr industries, in addition to diesel oil and normal gasoline production.

Petrofina has established their own new distribution in Germany in the last few years. The first stage of the refinery construction will have 20,000 bbl per day throughput. The second stage capacity will total 61,500 bbl per day. Production startup is scheduled for 1959.

Scholven Chemie (hydrogenation works). Besides stepping up production to quite an extent in the last few years (1958 and 1959 production is scheduled to total about 41,000 bbl per day), this company is producing large amounts of synthetic ammonia. Production of petrochemicals, especially polyethylene is also included in its operation. Shareholders are Hibernia, one of the very few government-owned enterprises among Germany's oil companies.

Deutsche Shell AG. Toward the end of 1958, Shell put on stream its new large refinery at Hohe Schaar in Hamburg. The whole Hamburg refinery (old and new one) of Shell has now a capacity of 61,500 bbl per day. Included are: One cat cracker, two platforming units, gas oil desulfurization and sulfur recovery units by the Claus oven process. An adjacent tank farm has a capacity of 12,300 bbl.

Another new refinery of Deutsche Shell is being constructed between Cologne and Bonn, capital of the German federal republic. It will have a capacity of 82,000 bbl per day and is scheduled to start operation about 1960. Light and heavy fuel oils, diesel oils, gasolines and jet fuels will be the main products. By-products will go to "Rheinische Olefinwerke," a joint enterprise of BASF and Shell. These plants are Germany's first large scale petrochemical enterprises and are producing high-pressure polyethylene, polystyrene and epicote resins. Their capacity has been considerably enlarged within the last few years. Crude oil will come through the "European Rotterdam Godorf pipeline."

Pipelines. Two large pipeline systems finally will provide overseas crude oils for the new and already existing refineries in the Rhine and Ruhr areas. One is from Wilhelmshafen on the North Sea, and the other is from Rotterdam, Netherlands.

Future Outlook

It is felt especially in Germany that the car market is by no means saturated, and in the next few years motorization will expand considerably and so will consumption of gasoline and diesel fuels.

Plans to enlarge existing roads, building auxiliary autobahns perhaps also in the Rhein valley, construction of new bitumen roads around cities, etc., will be necessary to alleviate the traffic jam situation already existing on many German "bottle neck roads." This will be a good opportunity for potential markets for the bitumen producing refineries.

The switch from coal to heating oil, especially in Germany, by industries and households has increased so rapidly, that large coal and coke heaps are now piling up in the "Ruhr" and in Belgium. Shorter working time for miners and the hope for stabilization of ever increasing coal prices are in prospect.

Even import cuts of cheap U.S. coal were discussed in daily newspapers although long range treaties for coal deliveries once concluded before and in the shadows of the now almost forgotten Suez crisis have to be considered.

The changeover from coal tar to oil as base material for petrochemicals is in full swing and goes on at a tremendous rate especially in Germany.

Although large expansion plans are going ahead in Middle Europe's refinery and petroleum areas and very strong competition already exists, the market is still perhaps the one which will be developed to the largest extent especially with regard to cars and to heating oils. Standard of living will still go up to a large extent and oil is surely giving the most important contribution.

★ ★ ★

REFINING PERSONALS

▸ After 25 years of service, **Dr. Eugene R. Smoley,** vice president of The Lummus Company, is retiring. However, he will continue to serve as consultant on a part time basis. He will also continue to be active in the work of the American Institute of Chemical Engineers for which he has just completed two years as national program chairman, the MIT Club of New York for which he was president 1957-1959. Dr. Smoley is author of many technical articles in the petroleum and chemical industry.

Dr. Smoley

Dr. Hersberger

▸ New general manager of the foreign marketing department at Atlantic Refining Company is **Dr. A. B. Hersberger** who will be responsible for the over-all program of foreign marketing involving foreign crude oils, finished products, marketing subsidiaries, and further market development. He will also direct certain domestic sales activities and continue as a member of the general marketing staff.

▸ Certificates of Appreciation were presented to **Dr. E. F. Voss,** Humble Oil and Refining Company, Houston, Texas, and **Dr. J. C. Geniesse,** Atlantic Refining Company, Philadelphia, Pennsylvania, by the Division of Refining of the American Petroleum Institute in recognition of their long and valued service and contributions to the advancement of petroleum technology.

▸ Newly appointed engineering consultant for Sun Oil Company is **Harold F. Elkin** who will coordinate all measures for the control of air and water pollution. He was formerly a sanitation engineer for the company.

▸ Two research scientists from Shell Development Company's Emeryville (California) laboratories will spend a year at Shell laboratories in The Netherlands. **Dr. J. H. Raley** will take an assignment in Amsterdam while **J. C. Dygert** will spend a year at The Hague.

It's New **REFINING EQUIPMENT**

NEW EQUIPMENT REFERENCE ANNUAL COMING JULY 15

The regular monthly NEW EQUIPMENT and NEW LITERATURE pages are omitted from this issue only. These popular features appear again in the August issue. Meanwhile, watch for the NEW EQUIPMENT REFERENCE ANNUAL, the latest and most complete reference manual of petroleum industry equipment, services, and products.

▸ **C. D. McLean** has been appointed group supervisor for products research and technical service at the El Segundo Laboratory of California Research Corporation. He joined the company in 1947 after receiving an MS degree in mechanical engineering at Oregon State College.

▸ **M. S. Beringer,** first man in the history of British American Oil Company to hold the dual post of president and board of directors chairman, has retired after more than 25 years with the company. He will continue as a member of the board.

The newly created position of petrochemical advisor to the manufacturing department at British American Oil has been filled by **J. L. Porter,** former process engineer.

▸ **Charles E. Hemminger** has received his 100th U. S. patent assigned to Esso Research and Engineering Company. He is the sole inventor of 82 of his patents which deal with nearly every major process developed by the company.

Named a research associate by Esso is **Winthrope C. Smith,** a chemist in the firm's technical sales service unit.

▸ Appointments at Humble Oil & Refining Company's Research and Development division, Baytown, Texas are: **E. A. Kelso,** senior research specialist; **A. M. Souby,** section head; **C. Phillips,** research specialist; and **T. S. Farmer,** senior research chemical engineer.

In the technical division **N. D. Jones Jr.** has been promoted to senior supervising engineer, and **M. E. Gillis** is now senior chemical engineer.

▸ The newly established "Montecatini" Fellowship, granted to an American student for study in Italy in the field of chemistry, has been awarded by the America-Italy Society to **Ronald A. Shelden,** an MSE candidate of Princeton University, for the academic year, September 1959 to June 1960.

▸ **Dr. Julius T. Banchero** has been named head of the University of Notre Dame's Department of Chemical Engineering effective September 1. He is currently professor of chemical and metallurgical engineering at the University of Michigan.

▸ National officers of the American Society of Lubrication Engineers for 1959-60 are: **Dr. A. B. Wilder,** E. I. duPont Company, president; **J. D. Lykins** (outgoing president), Wheeling Steel Corporation, chairman of the presidential council; **L. O. Witzenburg,** Farval Corporation, vice president at large.

Other new officers include **A. E. Cichelli,** Bethlehem Steel Corporation, secretary; **C. C. Blaisdell,** Penola Oil Company, treasurer; **C. L. Willey** was reappointed executive secretary. Regional vice presidents are: **D. P. Thomas,** Columbia-Geneva Steel Company, Western Region; and **J. Boase,** Lincoln Engineering Company, Canada Ltd., Canadian Region.

Additions to the board of directors are: **Dr. Earl G. Jackson,** General Electric Company; **Howard T. Peeples,** Timken Roller Bearing Company; **Dr. L. B. Sargent,** Aluminium Company of America, was elected industrial director.

▸ **Paul Siecke** has been named general manager of the Cincinnati Refinery of Gulf Oil Corporation, succeeding **Thomas F. Hogan** who is retiring. **Latham J. Lashley** will succeed Siecke as director of process design in the Pittsburgh office.

Other appointments made by Gulf Oil include **Edward J. Beetle** as manager of services at the Port Arthur, Texas, refinery, succeeding **Frank L. Bryan** who has been transferred to the manufacturing departmental headquarters in Houston as coordinator. **Bruce C. MacConnell** will take Beetle's place as director of accounting.

▸ Named operating superintendent of American Oil Company's Baltimore refinery is **G. W. Mayben.** He will succeed **William F. Mellendick** who is retiring after more than 42 years with Amoco.

▸ A $3000 supplemental award was accepted by **Milton E. Wales** and **Joseph M. Chustz,** retired employees of Esso Standard Oil Company's refinery in Baton Rouge, Louisiana, for an idea they submitted jointly through the company's employee-suggestion system. The suggestion, which has resulted in substantial economies in wax-unit shutdown and start-up procedures, was adopted four years ago when they earned only $50 each. The supplemental award was granted because it continued to produce savings in the refinery's wax units.

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Refining Books to Read . . .

Bibliography of Investment and Operating Costs for Chemical and Petroleum Plants, July 1954 — December 1956, *(Information Circular 7847), issued by the Bureau of Mines, 4800 Forbes Avenue, Pittsburgh 13, Pennsylvania.*

List of more than 500 articles and publications, fully indexed, compiled to aid the bureau's research programs.

Fabrication of Molybdenum, *published by the American Society for Metals, Book Department, 7301 Euclid Avenue, Cleveland 3, Ohio. Pages 221. Price $6.50.*

Much previously classified material appears in print for the first time in this book which contains 18 papers presented at the ASM conference in May 1958 at Los Angeles, California. Techniques covered include forming, welding, protection and coating.

Recirculation, *published by the Cooling Tower Institute, 420 Emerson Street, Palo Alto, California. Pages 12. Price $1.*

Description of a seven-year field research program on development of a recirculation factor for industrial water-cooling towers. Includes factors and recommended procedures.

Compilation of ASTM Standards on Plastics, *published by the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pennsylvania. Pages 1108. Price $8.*

Contains 43 standards, added by Committee D-20 on Plastics since the 1957 edition, relating to new plastic products, plus standards on plastic pipe and methods for short and long-term hydrostatic pressure tests of plastic pipe. Also includes tentative abbreviations developed as shorthand notation for generally used complicated chemical names.

Scale-Up in Practice, *edited by Richard Fleming, published by Reinhold Publishing Corporation, 430 Park Avenue, New York 22, New York, Pages 134. Price $4.50.*

Based on an "Experience in Industry" Symposium jointly sponsored by the Philadelphia-Wilmington Section of the American Institute of Chemical Engineers and the University of Pennsylvania, the book traces the development of laboratory achievement into commercial success. Chapters include scale-up theory, pilot plant operation, and the hazards of and methods for dealing with scale-up.

The Atom and the Energy Revolution, *by Norman Lansdell, published by Philosophical Library, Inc., 15 East 40th Street, New York 16, New York. Pages 200. Price $6.*

Here is a work for the general reader who wishes to grasp the social and political implications of the new scientific breakthrough — for the businessman who must adapt himself to the new economy —and for the specialist in any related field of inquiry. Subjects covered include: The atom, its energy and methods of releasing it; material sources of atomic energy; its exploitation by separate countries and by international bodies; and its impact upon the world as a whole.

Silicones, *by Robert N. Meals and Frederick M. Lewis, published by Reinhold Publishing Corporation, Dept. B-289, 430 Park Avenue, New York 22, New York. Pages 267. Price $5.95.*

Manufacture, properties and application of silicones are included, with data on properties of silicone resins, fluids and rubbers at high temperatures. Contains case histories of present industrial applications, and many new ones. Aimed at those interested in silicones as engineering and raw materials.

Symbolic Logic and Intelligent Machines *by Edmund C. Berkeley, published by Reinhold Publishing Corporation, Dept. B-290, 430 Park Avenue, New York 22, New York. Pages 203. Price $6.50.*

Principles, methods and purposes of symbolic logic and Boolean algebra, on which programming of intelligent machines is based, are explained in a practical manner by the author of "Giant Brains" and "Computers." Develops from answers to basic questions toward the ideas and terms needed to understand the subject as a whole. Design and principles of both small and large machines are included, along with specific problems that confront these machines.

Air Pollution Control *by W. L. Faith, published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, New York. Pages 259. Price $8.50.*

Written especially for non-specialists, this concise presentation of all important aspects of air pollution considers: its effects, influence of the weather on it, methods of measuring air contaminants, applicable control methods, and various legal problems related to it.

Petroleum Processing Principles and Applications, *by R. J. Hengstebeck, published by McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, New York. Pages 348. Price $10.*

Written by a practicing petroleum technologist, this reference guide provides a concise picture of the aims and methods of refining petroleum. Topics include products and raw materials, general operations, separation processes, catalytic cracking and reforming, isomerization, and many others.

API Recommended Practice for Electrical Installations in Petroleum Refineries. *Published by American Petroleum Institute, 50 West 50th Street, New York 20, New York. Pages 62. Price $2.*

Practices generally accepted in the petroleum industry, important features of electrical systems based on accepted design and installation practices proved by experience to be safe and economical are given in this first edition manual.

Oil-Shale Mine, Rifle, Colorado, a Review of Design Factors (Investigations 5429), *issued by the Bureau of Mines, 4800 Forbes Avenue, Pittsburgh 13, Pennsylvania.*

Detailed description of methods used in designing and operating the first experimental oil-shale mine at Rifle, Colorado, from 1945, when development began, to 1956, when mining was stopped.

PIPELINE INSPECTION

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☐	☐	We've been using tracked vehicles to get equipment into some locations.
☐	☐	We need a fast communication and coordination link between field units.
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HOW THE

Mediterranean Can Be Crossed

Oceanographic studies are now being made of two possible routes. Here is told the problems involved and construction methods being considered

Robert Venet
Societe d'Etudes du Transport et de la Valorisation des Gaz Naturels du Sahara

ANY DISCUSSION at the present time of the problems involved in laying a Trans-Mediterranean pipeline presents considerable difficulty. Although any engineer would feel perfectly at ease in discussing some operation already completed, he must necessarily feel somewhat loathe to expatiate on projects that are not merely still in course of study, but which have no existing precedent.

For this reason, the present article will not go so far as to advocate any particular solution to the problems raised, but will merely discuss them in the light of known facts. If, in so doing, it should give the impression of a certain reticence with regard to the possibilities of success, this impression is due, not to any personal pessimism on the part of the writer, but to the fact that it has been felt that an attitude of "Cartesian doubt" may, in the long run, prove more constructive than an over-facile optimism, for it is certain that long and arduous study must precede any final decision.

Two Possible Routes

Certain studies are being undertaken. Two special ships, the *Président Théodore Tissier* and the *Calypso* are investigating two possible routes. At the present time, they are still engaged on the oceanographic studies, prerequisite to the examination of the problems of a more technical nature, which later will be carried out by research departments, in the laboratory and at sea.

The routes being investigated are:

1. The Straits of Gibraltar (by the *Président Théodore Tissier*).
2. Along a rough line joining Oran to Cartagena (by the *Calypso*).

In the present state of our knowledge of oceanography, these two routes would appear to be most attractive in relation to location of gas producing wells and the principal consumer markets. Other routes may well be worth attention, however, particularly those crossing the Mediterranean on a level with Sicily and Sardinia, which may well prove in the end to be the only practical solution. The two routes referred to above, however, have the following general characteristics:

GIBRALTAR

Depth: About 250 fathoms.
Length: 20 miles.

Currents: Several knots at certain points on the surface, but little is really known about them at the moment.

ORAN-CARTAGENA

Depth: 1300 fathoms.

Length: 140 miles.

Currents: Probably weak, but little known.

These data do not include all factors that must be taken into consideration in choosing between the two routes. It is equally important to have detailed knowledge of the submarine relief and the geological characteristics of the

Map shows the possible points of Mediterranean crossing that are being considered.

Societe d'Etudes du Transport et de la Valorisation des Gaz Naturels du Sahara was created in association by C.F.P.(A), S.N.Repal, C.R.E.P.S., and B.R.P., and serves those companies as specialists on pipeline matters.

This article was translated from the French by David de Montalte.

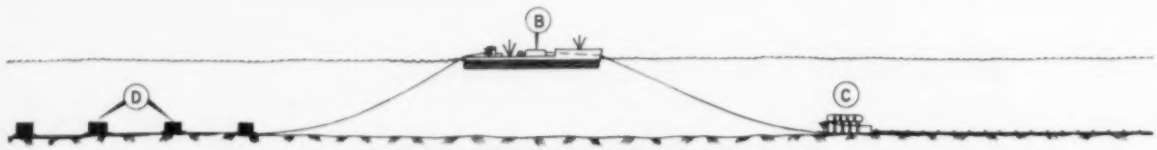


FIG. 1. TOWING ALONG SEA BED.

A — Pipe coupling point on land. B — Winch boat. C — Pipe sled.

sea-bed. The present oceanographic studies should supply much necessary information on the subject. Meanwhile, the three factors given above enable us to evaluate the problem in relation to past accomplishments.

What Has Been Done

With regard to submarine work already performed, it is generally agreed that the outstanding ones are:

The two 20-in. pipelines, some 40 fathoms deep and 5 miles long, carrying natural gas across the Mackinac Straits.

The 22-in. outfall pipe extending nearly 7 miles out to sea near Los Angeles at a depth of some 50 fathoms.

Both of these installations were made by towing the pipe along the sea-bed in accordance with the current practice of the Collins Construction Company, Inc.

Finally, in an allied field, the "Société pour l'Utilisation de l'Energie Thermique des Mers," succeeded in putting down a conduit, 450 ft long at a depth of 150 fathoms, off Abidjan (A.E.F.). This conduit, however, is somewhat different from the sea lines used to transport petroleum products. Because of its somewhat special function, it has a diameter of some 6 ft with walls only a few millimeters thick.

To give an idea of what the two suggested crossings involve, it should be noted that the length of the Gibraltar crossing is about twice as long and five times as deep as the Los Angeles sea line, whereas the Oran-Cartagena crossing is roughly 20 times as long and 26 times as deep.

What It Is Intended to Do

To provide the desired capacity, optimum diameter of any pipeline connecting North Africa to the principal European centers of consumption, should be approximately 40 in.

It probably will prove impossible to place a sealine of so large a diameter at any great depth (say 200 fathoms or more). It will be necessary, therefore, to replace the large diameter overland pipeline, at the sea-crossing, with several smaller diameter lines. This may well turn out to be an advantage, for, in order to allow sufficient safeguards for the maintenance of market supplies, it probably will prove necessary to lay at least two sections in the underwater areas. The importance of this last point cannot be stressed too strongly, for it is obvious that Saharan gas will only be able to find outlets in Europe, and the underwater sections of the pipeline must present the same security as the overland sections.

If this were not assured, companies would not risk committing themselves to investments opened up by the new source of energy, so that this highly important consideration must not be lost from sight when construction is underway.

Once the necessary precautions have been taken to safeguard uninterrupted supplies, everything points to the utilization of sealines of the largest possible diameter. To achieve a given throughput and friction factor, while maintaining pressure at a level comparable to that employed with large pipe, a great number of small pipelines would be necessary, and this would mean an increase in the cost of construction. Pressure, therefore, would have to be considerably increased; there has been talk of as high as 5000 psi. In defense of such pressures, it must be added that they do not cost much in steel, at least in those parts of the system laid at great depth and whose thickness must be calculated to resist compression when the line is empty. It should be noted, however, that two important problems must be solved in this connection:

1. The technique of compressors capable of operating on an industrial scale under such high pressure.
2. The fact that such pressures, which are already difficult to obtain under acceptable economic conditions, might well become very dangerous and unwieldy unless a number of precautions were taken in those parts of the pipeline situated just after the marine crossing, and which, for economic reasons, cannot be constructed to resist them.

Technical, as well as economic, considerations may, therefore, lead to the laying of two or three lines of intermediate diameter operating at some intermediate pressure. Such a solution might well prove to be the happy one.

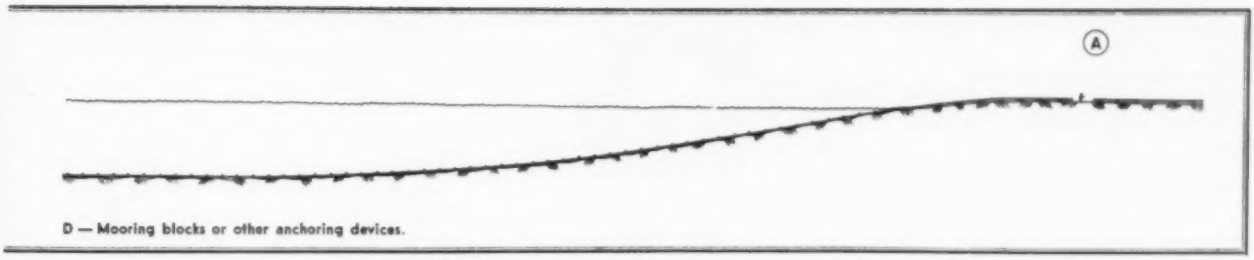
What Could Be Done

If the two methods cited earlier were adopted, following would be the procedures:

First method: The system employed in the Mackinac Straits and at Los Angeles consists essentially in welding

FIG. 2. SURFACE LAYING.

1 — Mooring blocks or other anchoring devices.
2 — Pontoons already cast off automatically after the pipe has been placed in position.
3 — Guide ropes with automatic cast off device.
4 — Underwater pipe coupling point.
5 — Antiswell pipe coupling platform.
6 — Pontoons holding the pipe under the surface for towing and coupling.
7 — Section of pipe ready for coupling.



D — Mooring blocks or other anchoring devices.

the pipe on land and towing it *along the sea-bed* from the departure to the arrival point. In order to reduce friction effects, the gross weight of the pipe is reduced by means of pontoons, which are cast off after the pipe is in place. In this way a residual weight of a few pounds per foot is obtained.

Second method: The method employed at Abidjan consists in laying the pipe *from the surface* in a series of sections prefabricated on land and coupled in the course of the laying operation.[1] Assembling is carried out on barges, which are rendered more or less impervious to swell by means of a judicious distribution of ballast and pontoons. The sections of pipe between the sea-bed and the surface is lightened, of course, by pontoons directly attached to the pipe.

It would seem difficult to imagine any other theories for laying pipelines, since bodies either must float or sink on immersion. Nevertheless, a number of variants, based on these two principles, are possible, and considerable ingenuity is being expended in perfecting them. The choice of a particular method at this juncture would present a somewhat delicate problem, and would, in any event, be premature, as it depends quite clearly on the results of the oceanographic studies, which are not yet known. Both methods present certain advantages and disadvantages, which will be discussed below, and which must be judged in relation to the specific characteristics of the particular crossing to be effected.

[1]Cf. Delaruelle Revue "Notre Sahara" N°5, July-August 1958.

Examination of Methods

Manner of execution. In the towing method the pipe is, to all intents and purposes, constructed as an ordinary landline. Quality of joints, therefore, can be proved under the same conditions as on land. In the second method, the coupling is effected at sea, and probably under water, with a view to limiting:

1. The curvature given to the free sections of pipe, and
2. The effects of hammering on that part of the pipe that is awash and which emerges from the water at an extremely acute angle, so that its weight varies with each wave by a quantity equal to the hydrostatic thrust on the lengths involved.

This being so, it will be necessary to perfect some system of coupling — by screwing or otherwise — which can be effected *under water*, and which can be subjected not only to ordinary pipe testing standards, as used in overland pipes, but also to a far more rigorous system of control. While a defective joint in an overland system results in a few repairs and a temporary stoppage in delivery, it is clear that the slightest defect in an underwater joint in the type of system envisaged, would lead to the total loss of the sealine, for it is difficult to conceive, at this juncture, how it would be possible to raise damaged sections laid at such a depth.

Stresses on Pipe

In the first method (by towing) stresses on the pipe include the following:

Hydrostatic pressure.
Drag from the tow cables.
Pressure set up by cross-currents.
Bending effect due to the topography of the sea-bed.
Accidental stress resulting from unforeseen obstacles.

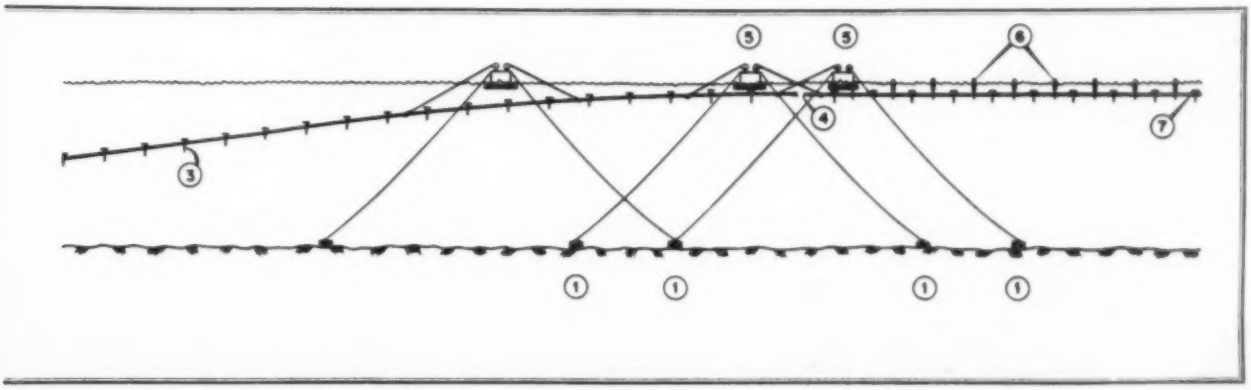
The first two categories of stress are well known or can be controlled down to a specific value. It is further possible to limit the effects of cross-currents by increasing the effective weight of the pipe, though this implies, needless to say, a corresponding increase in the drag necessary on the tow cables.[2] It is to be hoped, however, and this point should be confirmed by the present oceanographic studies, that the currents on the sea-bed are far weaker than those generally observed on the surface.

Stresses resulting from topographical effects, or unforeseen obstacles, limit the uses of this method, in our opinion, to beds devoid of pronounced features, which should be determined by detailed preliminary soundings and photographic reconnaissance. In this connection it should be noted that a relatively short crossing, such as the Straits of Gibraltar, is easier to reconnoiter, all other things being equal, than the Oran-Cartagena route.

In the second method, (laying the pipe from surface) stress on the pipeline includes the following:

Hydrostatic pressure.
An effect of curvature and drag, re-

[2]It is not impossible, however, to imagine a system of underwater guides reposing on the bottom and limiting the amplitude of possible lateral displacement of the pipe.



sulting from the shape taken by the pipe between the bed and the surface.

The effect of cross-currents.

After laying, a subsidiary tendency to curvature, resulting from the topography of the sea-bed.

The second category is worth considering for a moment. It would seem to be extremely difficult to learn exactly what happens when a pipe is suspended to a depth of hundreds of fathoms (in the Oran-Cartagena project, for example, where depth is 1300 fathoms) and for a length of more than six miles (even though the net weight is supposedly reduced to 1 or 2 lb per ft).

It is possible, of course, to build many hypotheses, some more convincing than others, by neglecting the inertia of the section, or simplifying the correct differential equation of equilibrium which is not linear and cannot be resolved in relation to elementary functions.

In our opinion this question will have to be studied in great detail for it should not be forgotten that, in accordance with the Mohr diagram, the stresses engendered by hydrostatic pressure must be combined with the stress of curvature in the course of laying, so that a buckling point may well be reached.

Furthermore, the consistence of the sea-bed has some bearing on the method of laying the pipeline, for the thrust of the sea-bed on the line counterbalances the bending moment at the point where the pipe leaves the sea-bed. This reaction is more or less concentrated in ratio with the modulus of reaction of the terrain in question.

The general run of these considerations can only be studied correctly with the aid of experiments on scale models, based on the results of the oceanographic studies, in the course of which a number of samples of the sea-bed will have to be examined. It can, however, already be stated that for effective weights of 1 lb per ft, it would be necessary to apply a surface drag of many tons to the section in course of laying, when the depth exceeds some 500 fathoms. This drag is roughly proportionate to the effective weight of the pipe for a given depth, provided the angle of inclination of the pipe near the surface remains constant. This, of course, leads to the remarks that follow.

It is by no means easy to regulate down to 1 lb per ft the effective weight of a pipe that out of water may well weigh more than a 100 lb per ft. It follows from this that, if the effective weight must be known within a margin of error of not more than 10 percent, the real weight must be known within a margin of error not exceeding 1/1000.[3]

Such accuracy is not current practice, and some method of controlling the weight will have to be studied. It should be noted that this remark is equally applicable to the system of towing. In this case, however, it is only the mean effective weight of the entire section to be laid that must be taken into consideration in calculating the drag to be applied on the tow cable. On the other hand, in the second method, stress on the section in course of being laid is in direct proportion to the effective weight of that section between the surface and the sea-bed.

A system will have to be worked out that will permit the continuous and safe transfer of the drag or stress (calculated above at several tons) from one point to another in the pipe string, as the laying of the pipe advances. It must be stressed that any interruption in the drag[4] will result almost certainly in the loss of the pipeline.

The method of laying from the surface would not appear to be compatible with any fairly strong cross-currents, for their action would very rapidly overcome the effective weight of the pipe, which would tend to veer under the action of the two forces, and probably would prove impossible to control. The restraining effect of the anti-swell platforms would tend to increase, furthermore, in ratio with the intensity of the currents.

Stresses resulting from curvature at the point of contact with the sea-bed and near the surface increase with the diameter of the pipe, so that this method tends to limit the diameter of the pipe to relatively small dimensions. In order to reduce these stresses at Abidjan, the conduit was equipped with flexible couplings, but it would appear very difficult to use such joints in a pipeline subject to high pressures at great depth. Problems created by small diameter pipelines, particularly with regard to internal pressure, already have been discussed.

The great advantage of the surface method lies in the fact that the means to be employed depend solely on the depth at which the pipeline is to be laid and are independent of the length of the marine crossing. With the other method, however, the means to be employed are, generally speaking, dictated by the length.

The purely nautical problems raised by the two methods are best left to the consideration of seamen, though it should be noted that, even supposing the risks of storm damage to the floating barges remain the same regardless of the method employed, the effects of their destruction would not be identical.

In the towing method, the problem would amount to no more than recovering the tow cable, which should not present much difficulty, in fact, would present none if the precaution of hitching the cable to a buoy had been taken. Once the barges had been replaced, it would merely be a question of continuing the towing operations.

In the other method, the destruction of the floating engines would seem to imply the total loss of the pipeline.

It has already been pointed out above, that the method of towing along the sea-bed can only be envisaged in cases where the bottom does not present any serious obstacles. It would seem, however, that in this regard, surface laying can be adapted to far more uneven beds. If one considers the use of pontoons to lighten the sections of pipe during laying operations, which are cast off near the sea-bed by means of guide ropes or some similar system, it is evident that in cases where the pipe has to cross crevasses, the pontoons situated above the crevasses will not be liberated, the pipe thus bridges the crevasses. This could only be possible, however, if the stress imposed by the span did not exceed the strength of the pipe, which should be considerable when the effective weight is reduced to 1 or 2 lb per ft. It should be noted that in such cases, the life of the pipeline will depend on that of the pontoons. But it would appear difficult, from an economic point of view, to construct pontoons, and their system of fixation, having a probable life equal to that of the pipeline itself. Of course, it is possible to conceive the placing of reinforced pontoons just in those places where preliminary soundings have shown considerable uneveness of topography.

These considerations lead us to make a few remarks on the characteristics common to both methods, in particular to the risks of corrosion, and the problem of the construction of pontoons to reduce effective weight.

Corrosion

Subject to complementary study, it would not appear that the protection of underwater pipelines against corrosion should prove particularly difficult, or at least no more difficult than the protection of overland pipelines. It would seem probable that a pipeline reposing on a sea-bed at a depth greater than 50 fathoms would be better protected than a pipeline crossing an urban district subject to a multitude of stray electric currents.

[3] It should be noted in this respect that the margin for error in the thickness of pipe, according to API standards, is a little over 10 percent.

[4] Caused, for example, by a break in the retaining cable or in the mooring of the floating platform from which the pull is being made.

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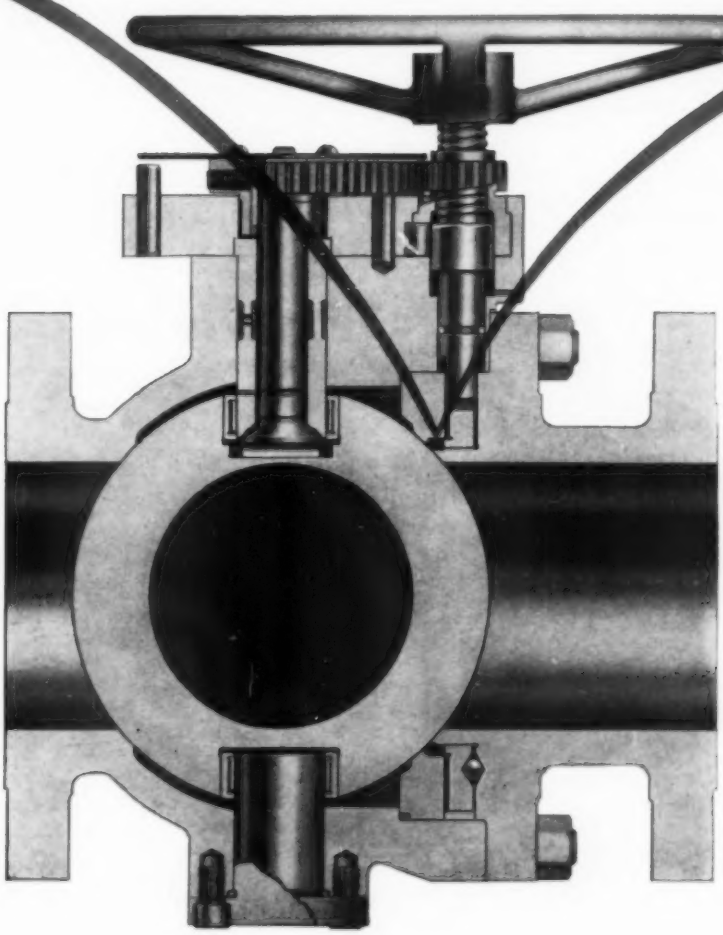

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It can be expected, however, that pipelines lying in shallows having a high oxygen content, would be exposed to more active corrosion, but they can be protected by known methods, for the problem is by no means new. Lines of considerable length already have been laid in shallow sea-water. In the case of sea-beds having a low oxygen content there arises the problem of corrosion caused by micro-organisms, which reduce sulfates and cause the liberation of hydrogen sulfide.

Methods employed in the protection of long sealines already constructed, usually have been based on a certain number of coats of bituminous or tar enamels, reinforced with glass fiber. These coats are applied directly to the steel after due preparation. Outside this is placed a layer of concrete reinforced with a wire netting. The concrete protects the enamel from mechanical erosion, while the enamel serves as a protection against the corrosion itself.

Protection of the pipe can be made complete by application of cathodic protection.

To date, and particularly with regard to problems of corrosion, we have taken it for granted that the pipeline was made of steel. The use of other materials is perhaps possible.

There has been some talk, for example, of plastics whose mechanical strength and chemical qualities have been much discussed. In the case of deep sealines, the first necessity is resistance to external compression, but the critical pressure is not merely a function of the instantaneous modulus of elasticity of the material employed, but also depends on the differed modulus — that is to say, the modulus after taking into consideration the creep factor. One cannot, therefore, base oneself on tensile strength alone. A decision concerning the usefulness of any particular plastic must take into account all these different elements, and even then it must be subject to the cost of the material.

Pontoons

The two different methods that have been described briefly in this article, both necessitate the use of pontoons to reduce as far as possible the effective weight of the pipeline in the course of laying operation.

We have taken for granted the solving of this problem, whereas, in fact, it is by no means a simple matter to manufacture a vessel having a large degree of buoyancy and at the same time is capable of resisting great external pressure. When depth is increased to, say, 250 fathoms or more, the pressure becomes so great that one is obliged to reinforce the walls of the pontoons in order to avoid compression, and, in that event, their price and weight increase rapidly.

In order to avoid this drawback various methods have been envisaged:

1. Filling the pontoons with some liquid having a lower density than water. This solution protects the pontoon from external pressure, but unfortunately there does not exist a liquid whose density is considerably lower than that of water. Hydrocarbons would appear the only liquid that could be used, but they have a density in the area of 0.6 to 0.7 and, for this reason, the efficiency of the pontoons would be reduced and their size increased.

2. Pressurizing the pontoons by means of a gas is a satisfactory solution for depths up to 50 fathoms. For greater depths, there are certain disadvantages, for the pontoons must be filled with gas at a pressure approximating the pressure existing at the maximum depth at which the pipe is to be laid, while at the same time they must be able to resist the internal pressure when they are at the surface. Where the pressures are likely to attain hundreds or even thousands of psi, the necessary reinforcement results in the pontoons becoming costly and unwieldy. Nevertheless, patents have been taken out for certain devices designed to maintain at a constant level the differences between the internal and external pressures. The perfecting of such instruments will considerably simplify the construction of pontoons.

It is our hope that having reached the end of this article, the reader will have gained some idea of the difficulties involved in the laying of a Trans-Mediterranean pipeline. Solution of the many problems presupposes the carrying out of detailed preliminary studies, which will, no doubt, continue over a number of years.

It is, however, to be expected that once the present oceanographic studies have been completed, sufficient information will be available to direct the remaining studies more accurately, and to reach a decision concerning the method to be used in laying the pipeline. Meanwhile, the extreme importance of these studies, and the care and attention that must be given to the analysis and interpretation of the results achieved, cannot be sufficiently stressed. ★ ★ ★

How Do Pipeliners Get Injured?

Although our accident record has been kept far below the average for like phases of operation in the oil industry, we still realize that our attitude toward accident prevention must be improved as long as we have accidents at all.

To give a clearer understanding of the types of accidents that should be watched for, and the ways to prevent them, a study was made of our record for the last 10 years, including reasons for the accidents and ways they might have been prevented.

Records indicate that most injuries happen to the eyes, fingers, and back, and that these parts of the body suffer the most severe injuries.

Eye injuries can be reduced by wearing protective equipment. Protective measures for finger injuries include, first of all, careful working habits and avoiding unnecessary hazards that cause accidents.

Back injuries are almost never minor. They are the most painful, longest disabling, and the most expensive. Most of these back injuries could be prevented by remembering these few safe lifting methods:

Get a good grip on the object.
Bend the knees to keep the back straight.
Keep the load close to the body.
Lift with the legs instead of the back.
Get help with large or heavy objects.
Use power equipment to do the lifting whenever possible.

Safety devices and reductions in safety hazards cannot keep accidents from happening unless every employee keeps constantly alert to using safe working methods.

Proof that a safety-conscious attitude prevents accidents was startlingly portrayed by several comparisons made through this study. One was that in the years in which we had our first-aid training programs, our accident frequency rate was at its lowest, whereas every other year it was at a higher rate. The chances of this happening are 1 in 40, and yet it has happened four consecutive times.

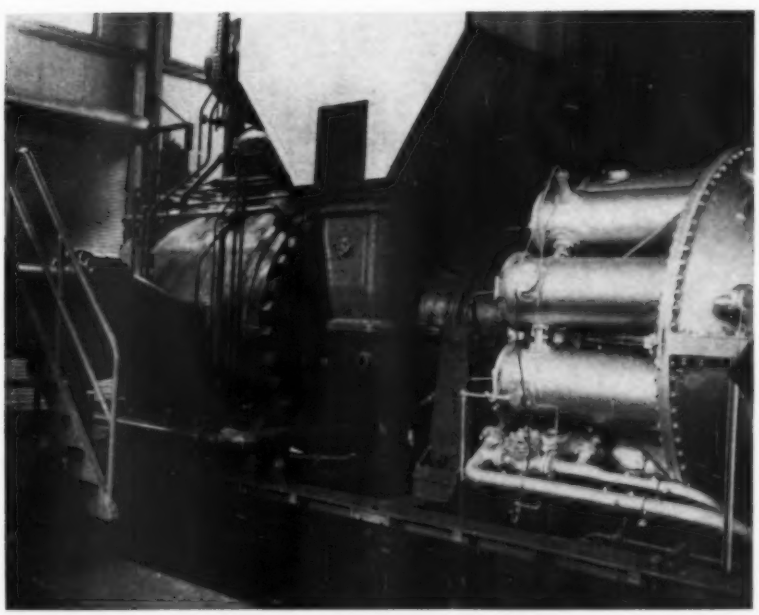
More than by chance, our lowest frequency rates can be attributed to the fact that first-aid training must cause a safety consciousness that helps keep accidents down. The value of safety consciousness, therefore, is more than just a reasonable theory. — Condensed from *The Go-Devil*, publication of Shell Pipe Line Corporation, Houston, Texas.

From this console at control station a satellite station 28 miles away is started and stopped by the push of a button.

New Stations Feature 13,400-Hp Gas Turbines

Low installation cost, low operating cost designed into four remotely controlled stations on Texas Eastern's system

Frank H. Love, *Editor*



At satellite stations a single 13,400-hp gas turbine powers a centrifugal compressor. The gas turbines are the largest ever applied to gas transmission operations.

TEXAS Eastern Transmission Corporation has installed four compressor stations on the Penn-Jersey section of its system that represent a new concept in automatically remote controlled stations. The new stations are at Shermans Dale, Bernville, Armagh, and Entriken, Pennsylvania, each controlled by an upstream station approximately 40 miles distant. The stations are all on that portion of Texas Eastern's line between Oakford underground storage near Pittsburgh and Lambertsville, New Jersey, and will be used for winter peaking.

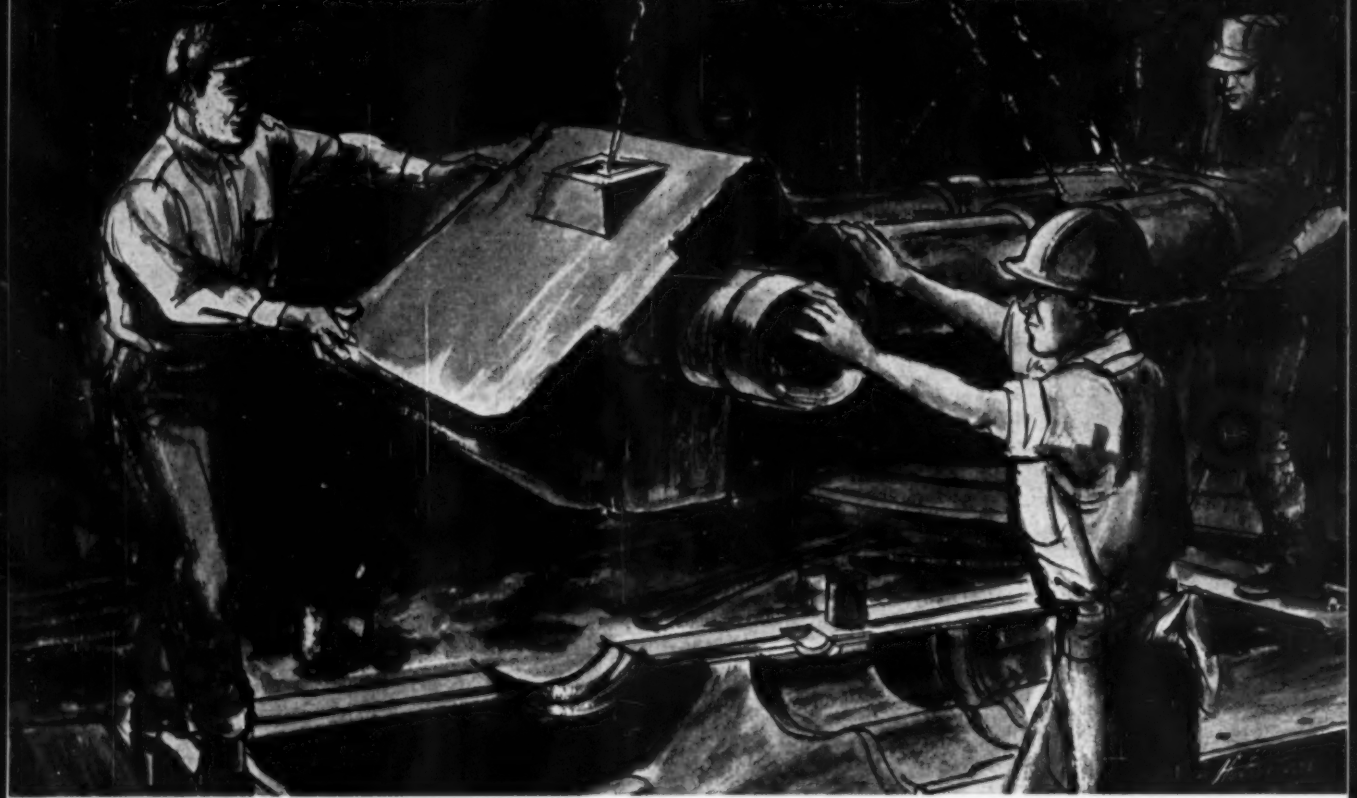
Gas compression is provided by a centrifugal compressor powered by a 13,400-hp gas turbine, largest gas turbine ever applied to gas transmission operations. By centralizing large horsepower in a single unit the company was able to construct the stations at the relatively low cost of $2,500,000 each, or $196.96 per horsepower. Among the economies effected by use of one large unit was the elimination of a basement, the station being built on a slab type foundation. There are also other outstanding design features. Overall these are:

- **Largest gas turbine ever used for natural gas transmission.**
- **Because of its remote control feature, design has been kept simple, incorporating the use of a single shaft, simple cycle turbine.**
- **Low initial cost resulting from large horsepower in a single unit with accompanying simple design, such as slab construction and no basement.**
- **Low operating costs resulting from remote control features.**
- **Control system will sustain operation during short outage periods of purchased auxiliary power.**
- **First use of a synthetic fire resistant lubricant throughout a station, to minimize fire hazards associated with natural petroleum lubricants.**

Remote Control System

Each of the "satellite" or controlled stations has an identical control system. The controlled and control stations are tied together by leased, common carrier communication facilities, consisting of four metallic wire circuits (two pairs of wires) for each system. One pair transmits controlling functions, i.e., transmission of actuating signals; the other pair transmits intelligence, i.e., transmission of alarm and telemetering information from satellite to control station.

FOUND IN THE FOUNDRY



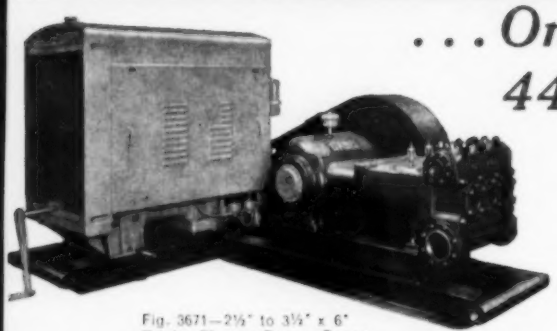


Fig. 3671—2½" to 3½" x 6" Triplex Plunger Pump. Capacities of 191 to 375 barrels per hour at working pressures from 1575 to 800 PSI.

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Fifteen functions are telemetered from the satellite to the control station: (1) Station suction pressure, (2) station discharge pressure, (3) station suction temperature, (4) station discharge temperature, (5) station ambient air temperature, (6) turbine exhaust temperature Group 1, (7) turbine exhaust temperature Group 2, (8) wheel space temperature #1 Fwd., (9) wheel space temperature #1 Aft., (10) wheel space temperature #2 Fwd., (11) wheel space temperature #2 Aft., (12) turbine load factor, (13) unit suction pressure, (14) turbine governor set point, and (15) turbine speed.

The first 13 of these functions are translated by 5-sec impulse duration-type telemetering. Functions 14 and 15 are translated by 5 pulses per second impulse duration-type telemetering. In addition, the first 5 functions are time multiplexed (share one teletype channel) through the application of time multiplex equipment. Functions 6 through 11 share 3 teletype channels through the application of the same instrumentation.

All instrumentation, alarm and indicating lights, control switches, and mimic bus for control of a satellite station are housed in a console at the control station, arranged to give the operator a clear picture of actual conditions at the controlled station.

In designing the supervisory and other remote control equipment, special attention was given to several factors. One of the most important was control of compressor surge at the satellite stations. This is taken care of by a device known as the Surgetrol, developed by one of Texas Eastern's own engineering staff and in use by the company at other stations. The device senses surge conditions as they begin to develop and recycles gas through the compressor until the surge ceases. The equipment consists of a differential transducer connected to the discharge side of the gas compressor, which supplies an electrical signal to a highly stabilized low pass amplifier. This amplifier determines whether surge exists and through the auxiliary relay circuit opens the station recycle valve. During the start-up surge condition, the recycle valve is kept from opening until the unit is on the line by locking out the auxiliary relay circuit by sensing the position of the unit suction valve.

Another important design feature is the provision that has been made for continued operation of instruments in case of power failure. In such an event, instruments requiring a-c power are automatically shifted to an inverter, which runs off storage batteries.

Minimum sustaining speed on the turbine is approximately 3800 rpm, so for purposes of accuracy and ease of comparison with governor set point, the lower 78 percent of turbine speed is suppressed automatically, i.e., only speeds above 3800 rpm are transmitted to the control station.

Size of turbine necessitated tall building structure, but slab foundation design and elimination of basement contributed to low initial cost of stations.

Station and Turbine Controls

Stations were designed with two criteria uppermost: (1) The system must be fail-safe in every respect, and (2) the station must continue to run on a purchased power outage until such time as the auxiliary generator picks up the load. Should the generator fail and purchase power still be unavailable, then the turbine will shutdown safely with a 125-v nickel cadmium battery supplying the power for a safe shutdown and securing the station.

Station and turbine duplex control panels essentially are two matching sections. In the station section are the control relaying, protective devices and instrumentation associated solely with the station. The other section contains similar equipment associated solely with the turbine. Adjacent to these sections is the supervisory equipment, thus grouping all the controls.

Two turbine control busses are required to meet the exacting demands of this completely fail-safe system and the "carry-over" concept on power control, a 125-v d-c bus and a 120-v a-c bus, both solidly grounded.

Utilizing the d-c bus as the prime control system bus, sequence is forced automatically. Sequence is completely fail-safe and loss of intelligence or a component failure will cause a shutdown.

The station is completely self protected within itself, and is not dependent upon the continuity of the supervisory control equipment or the supervisory channels. The station master selector is arranged so that station control can be transferred to the controlling station or to the local position at the duplex board. This can be done even while the station is running.

Starting Sequence

Before the turbine can be started all auxiliary, control, and safe run switches must be on. Valves must be in these positions: Station suction and discharge open; station vent, unit suction and unit discharge closed; unit vent open; unit pressurizing and unit recycle closed. If these conditions have been fulfilled the amber check and permissive start lights will be lit.

The start-stop switch is now moved to the start position and the following action takes place: Auxiliary lube oil pump starts, vapor extractor starts, lube oil cooling water pump starts, and seal oil pump starts.

When normal operating conditions are reached, the main turbine clutch, turning gear motor, and turning gear clutch are engaged. After one minute the unit pressurizing valve begins to open, and when it has completely opened, its limit switch opens the starting turbine gas isolation and minimum speed valves and the turbine begins accelerating toward 30 percent speed, and the turning gear clutch is disengaged.

When turbine speed reaches 30 percent, turbine purge begins. This requires three minutes, then the spark plugs are energized, minimum fuel gas

is admitted to the combustors by picking up the hydraulic control oil system, and the firing time delay relay is energized.

If combustion does not take place within 15 sec, a shutdown sequence is initiated as the firing time delay relay times out. If ignition occurs and flame is detected, the first step fuel limit valve is energized to reduce the fuel to a minimum of combustion, and a three-minute warmup period begins.

At the end of the warmup period, the first step starting turbine acceleration valve is energized and the turbine accelerated to 35 percent, at which speed additional fuel is added by deenergizing the first fuel step limit valve. A second three-minute warmup period now begins, at the end of which the second step starting turbine acceleration valve is energized and the turbine is accelerated to 50 percent speed. At this speed the second step fuel limit valve is energized and the turbine accelerates to 78 percent speed. As the 78 percent speed is reached, the third step fuel limit valve is energized and the turbine is now self-sustaining.

The starting turbine gas isolation valve now closes and the main turbine clutch is disengaged. Unit suction and discharge valves begin to open, and when they are both 2 percent open the unit vent valve begins to close. When the unit suction valve reaches a preset open position (about 25 percent), it stops its travel and the unit pressurizing valve begins to close. After the unit discharge valve is 100 percent open, further opening of the unit suction valve is dictated by the load controller.

The station is now on the line, and turbine speed is under control of the speed governor.

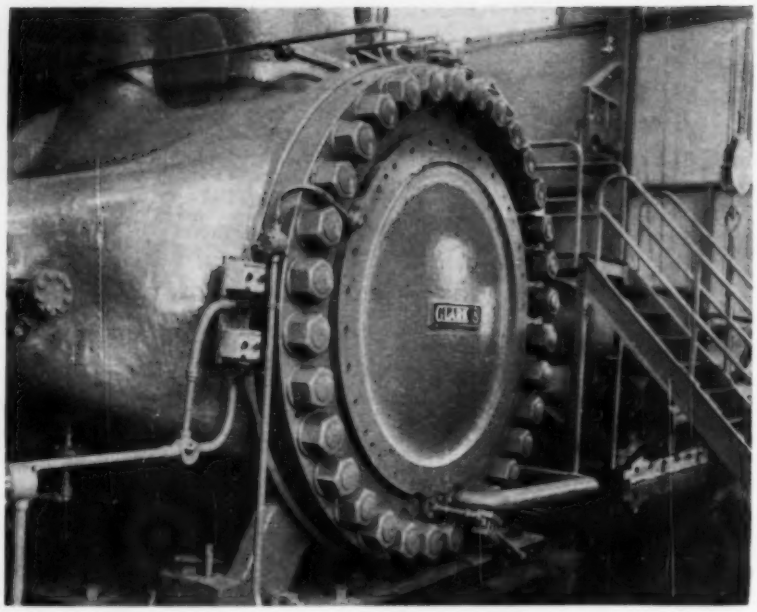
Shutdown Sequence

To shut a unit down the start-stop switch is moved to the stop position. This dumps the hydraulic control oil system, cutting off fuel to the turbine. The unit suction and discharge valves begin to close and the unit vent valve begins to open. When the unit vent valve is entirely open the seal oil pump stops.

When pressure drops to 46 psi, or speed declines to less than 78 percent, the auxiliary lube oil pump starts.

As the turbine decelerates, a timing relay is energized, and after the turbine is at a standstill (zero rpm), the timer brings in the turning gear motor and its clutch and also the main turbine clutch, and the turbine is now in a 48-hr cool-down cycle. The turbine may be restarted at any time during the cool-down period, however.

It should be noted that any shutdown protective device will cause this shutdown sequence to occur automatically.

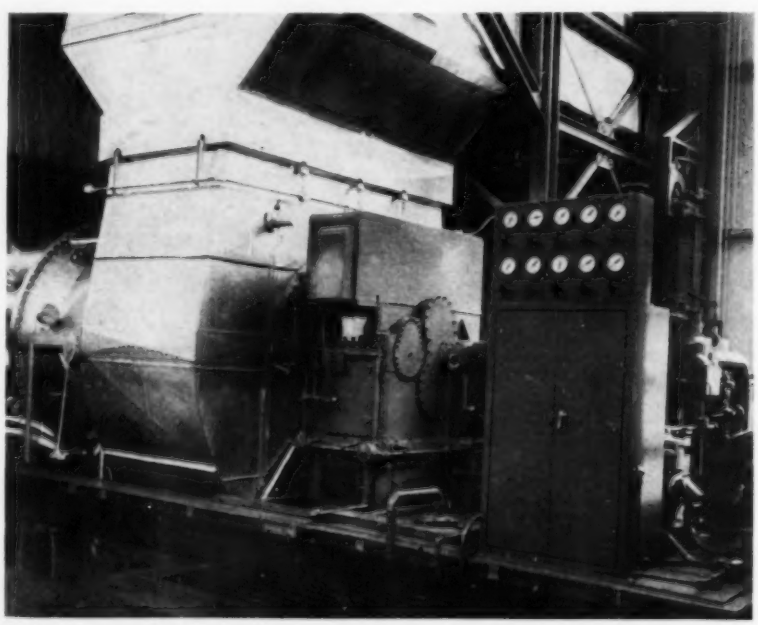


Centrifugal compressors at new stations are two-stage, uncooled, high speed, high pressure, single suction units with 37-in. nominal size impellers.

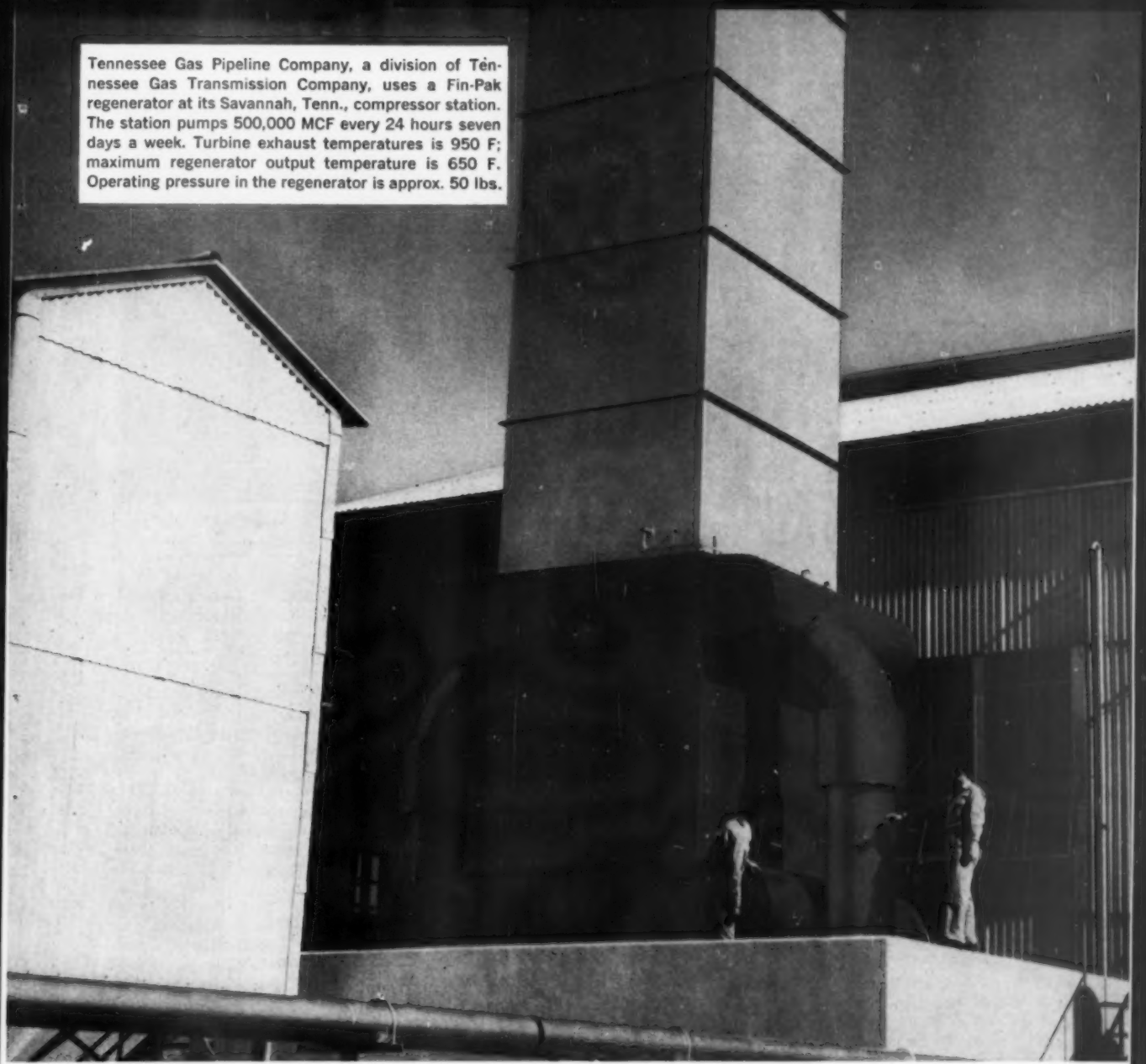
In addition, an emergency shutdown causes the station suction and discharge valves to close and the station blowdown valve to open and exhaust the station piping to atmosphere.

Main Compressor Units

Gas turbine. The 13,400-hp gas turbine prime mover is a simple cycle, single shaft unit. Its rated horsepower is based on 4860 rpm at a 1000-ft altitude and 80 F ambient temperature. At rated conditions, heat rate is specified to be not greater than 12,250 Btu per bhp, which corresponds to a thermal efficiency of 20.8 percent. Higher output capacity is obtained as the ambient temperature is lowered, by the very nature of the gas turbine. This condition exists because the air density is increased as its temperature is lowered and a greater mass flow passes



Turbines' rated 13,400-hp is at 4860 rpm, 1000-ft altitude, and 80 F ambient temperature . . . but can deliver 30 to 40 percent additional power as ambient temperature approaches zero.



Tennessee Gas Pipeline Company, a division of Tennessee Gas Transmission Company, uses a Fin-Pak regenerator at its Savannah, Tenn., compressor station. The station pumps 500,000 MCF every 24 hours seven days a week. Turbine exhaust temperatures is 950 F; maximum regenerator output temperature is 650 F. Operating pressure in the regenerator is approx. 50 lbs.

FIN-PAK HEAT EXCHANGER CUTS FUEL COSTS 32%

An Air Preheater Fin-Pak can pay for itself in approximately 6 months *on fuel savings alone*. For example, a Fin-Pak with a designed effectiveness of 75%, in a gas turbine cycle at 6 to 1 pressure, and a turbine inlet temperature of 1500°F, can cut fuel costs by 32%. And the improved combustion you get with a Fin-Pak reduces residual carbon deposits, cuts maintenance of other equipment in the system.

Fin-Pak provides big installation savings, too. It's compact (takes less than half the space of tubular regenerators of identical capacity) and weighs 50% less than an equally efficient tubular unit — so it's easier to erect and needs less expensive support structure.

No maintenance is required, other than infrequent cleaning with compressed air. The Fin-Pak has short, straight-through passages that facilitate cleaning.

ONE LAST THOUGHT: A gas turbine station requires approximately 80% *less* plant maintenance personnel than a station of equal capacity operating with diesels, steam turbines or gas engines. You can economize still further by incorporating a Fin-Pak in the gas turbine cycle. For complete details, call or write The Air Preheater Corporation.

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.

through the almost constant volume compressor. Output capacity increases in direct proportion to the increased air density, so this turbine should deliver between 30 and 40 percent additional power above the 80 F rating of 13,400 hp when the ambient temperature approaches zero F. Unit efficiency also improves as the ambient temperature drops, and an increase in thermal efficiency up to 7 points is expected at extremely low temperatures.

The turbine is complete with air silencer, expansion gas starting turbine, load coupling, lube oil system with tank and pumps, fuel gas system, ignition system, control panel, motor starter equipment, auxiliary switchgear, and distribution equipment.

In design, the turbine is split along its entire length at the horizontal centerline. Four individual top casing sections can be removed separately without taking the unit off its base or affecting its lineup. This makes all bearings accessible for inspection and all rotating parts removable without disturbing the lower half.

The turbine is supported on a fabricated steel base, which also contains a lube oil tank, piping, and integral wiring for the turbine. The 1200-gal lube oil tank is equipped with high and low level protective alarms.

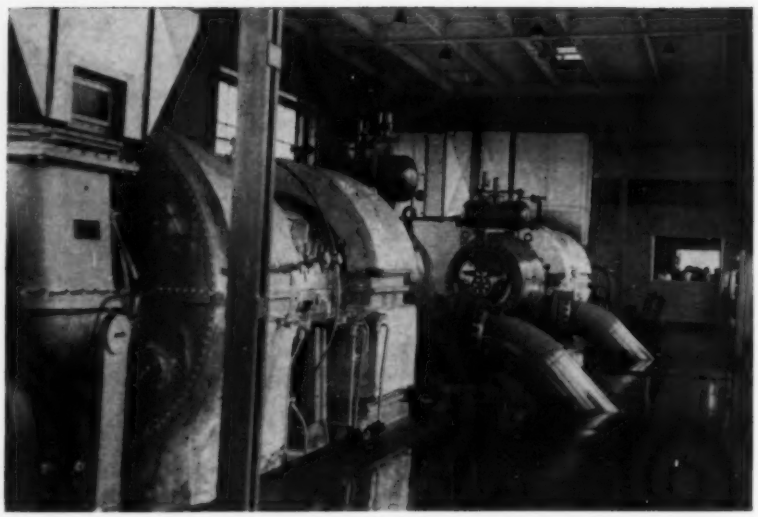
Other turbine accessories include a mechanical-hydraulic governing system, starting and supervisory control equipment, vibration and high exhaust temperature shutdown protective devices, and flame arrestors.

Compressor. The compressor is a two-stage, uncooled, high speed, high pressure, single suction centrifugal with 37-in. nominal size impellers. Being of barrel construction, the hydraulic internals can be removed and changed for varying flow conditions. The two impellers are mounted back-to-back, thus the thrust on startup and in normal operation tends to be balanced. High total weight of the unit helps to maintain proper alignment.

Compressor operating characteristics are:

Suction pressure: 644 psia
Discharge pressure: 969 psia
Compression ratio: 1.504
Rated volume inlet: 10,830 CFM
Rated head: 17,660 ft lb/lb
Rated rpm: 4860
Horsepower required for design conditions: 15,900 (40 F rating of turbine).

Lubricating and seal oil system. Because the stations are unattended, and in light of previous experience, Texas Eastern is using a fire resistant synthetic lubricant for lubrication of all moving parts of the turbines and compressors, as a sealing media to prevent gas from leaking from the compressor into the compressor building, and for lubricating flexible couplings, starting turbines, and control devices.



Control stations, built in 1957, have three 5000-hp gas turbines driving centrifugal compressors. Turbines require no water service . . . lube oil cooling system is oil-to-air.

The lubricant has a phosphate ester base and, although used experimentally in small steam turbines, has not been used in large machines and never before applied to a gas turbine compressor unit.

Use of the lubricant necessitated some modifications in the lube oil, seal oil, and control oil systems. Generally, the changes consisted of substitution of compatible parts for incompatible gaskets, packings, "O" rings, thread compounds, etc. Pump impellers were reduced in diameter to facilitate their operation in the heavier fluid. To assure satisfactory operation in extremely cold weather external storage tanks are provided with heat, insulation, and recirculation.

As originally designed, these units were to operate with oil-to-air heat exchangers, but because of the lubricant's pour point, the systems were revamped to make use of lubricant-to-water heat exchange within the heated building and water-to-air heat exchange externally.

Lubricant in the reservoir built into the base of the turbine is kept at a minimum temperature of 70 F by six electric immersion heaters in the reservoir and by the turbine room space heaters.

The lubricating and sealing system is a closed one and lubricant pumped from the turbine base reservoir flows through the tube-and-shell heat exchanger, a magnetic filter, a primary filter, and a secondary filter before it reaches the bearings and seals. It then drains back to the turbine base reservoir.

Make-up lubricant is moved from the storage tank to the turbine sump by controlled air pressure, through a filter, a meter, and to the reservoir tank.

Control Stations

The stations that control the four remotely operated stations are located at Lilly, Perulack, Grantville, and Bechtelsville, Pennsylvania. They are original stations on the Penn-Jersey pipeline, placed in operation in 1957. Pumping equipment consists of three 5000-hp gas turbine driving centrifugal compressors. A feature of these particular gas turbines is that they require no water service, rather an oil-to-air lube oil cooling system is used.

Turbines are two-shaft, compound open cycle, mechanical drive units with regenerator and variable speed control. Power gas turbine speed is designed at 6000 rpm, and axial air compressor speed at 6200 rpm. Regenerators consist of 16 bundles of 13 envelopes arranged for counterflow of exhaust gases and compressed air. Capacity is 98 lb of compressed air per second.

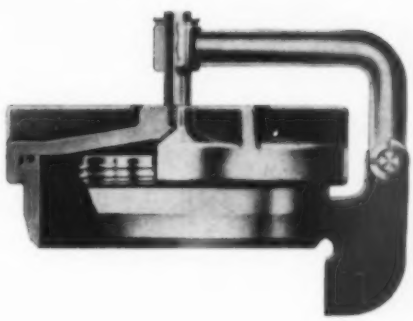
Compressors are single stage, single suction centrifugals with overhung 28½-in. diam impellers. The units have 24-in. flanges and vertical cover plates for repair accessibility and fixed angle inlet guide vanes. The three compressors are operated in series. First stage takes suction at 578 psi and discharges at 691 psi. The second stage discharges at 831 psi and the third stage at 995 psi.

The control stations are fully manned, of course, having a station personnel of one chief operator, four operators (one per 8-hr shift), one relief operator, one mechanic's helper, one maintenance man, and one repairman. ★ ★ ★

There's no faster, easier way to start a pig than through a 2-Piece Blank Cap. Coarse, precision-cut threads permit the cap to be backed off in seconds; four-way adjustable hinges permit even the largest sizes to be balanced and aligned perfectly for easy handling by one man.

With a 2-Piece Blank Cap, there are no small threads to cross or gall — no fumbling with adjustable wrenches—no bolts to bend or lose—no hammering. Instead, there's just the two pieces, rough, tough and man-sized, for a man-sized job.

Check the many features of safety, dependability and economy offered by 2-Piece Blank Caps. Check with the many major transmission companies whose systems are equipped throughout with them. Then, you too will specify 2-Piece Blank Caps for your scraper traps and strainers.



2-Piece Blank Caps are supplied in sizes from 2" through 38", in ASA series 150, 300, 400, 600 and 900. Dependable O-Ring seal for vacuum or pressure service. For complete information, write for Catalog No. 57.

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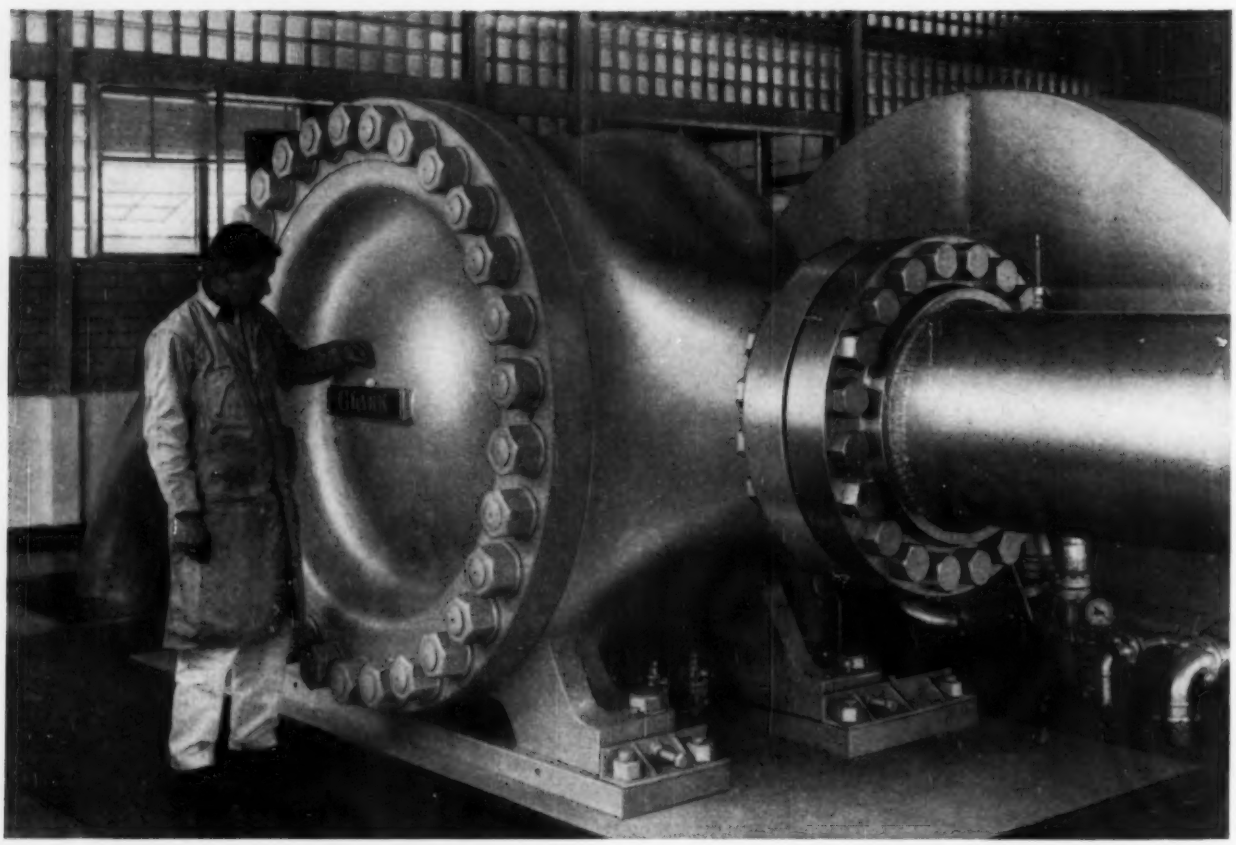

Clark Pipeline Compressors are available in five flange sizes: 12x12, 16x16, 20x20, 24x24, 30x30

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They're the boosters with a built-in future

Clark centrifugal pipeline compressors, designed specifically to meet gas transmission requirements, are built to meet the future.

Now extensive changes in operating conditions can be handled within the same case at minimum cost and without sacrificing efficiency. Clark design permits replacement of the volute, as well as guide vanes and impeller, with components having completely different characteristics.

Key to this versatility is the design of the volute as an insert, not as an integral part of the case. Changes are made quickly—just remove the case cover, pull the insert, install a new one. The unit remains perfectly matched, and no piping modification is required.

This versatility is supported by other special Clark features. Extra heavy and rugged cases withstand stress from pipe expansion without distortion. A single oil film type seal provides positive, gas-tight sealing during operation and at shutdown.

Many of these units are operating on the nation's gas transmission pipelines, driven by gas turbines, steam turbines or electric motors. They are supported by Clark's encyclopedia of experience. Your nearest Clark office will gladly give you all the facts and figures.

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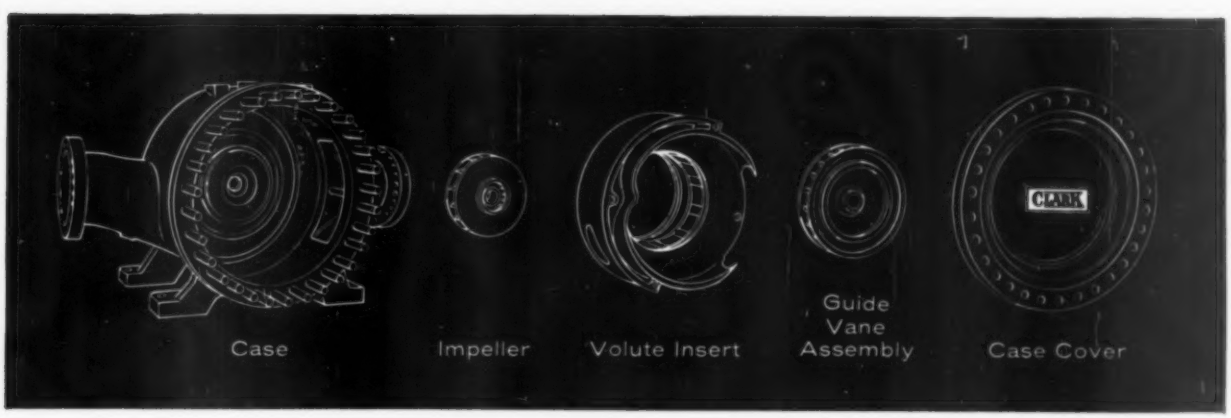
CLARK **Centrifugal Pipeline Compressors**



Complete internal assembly is easily interchanged to meet future conditions.

Automatic Throughput Control And Constant Torque Achieved

Installation demonstrates that engine speed can be varied for desired discharge pressure with compressor pockets operated independently for full torque

Olin P. Drake
Senior Staff Engineer
Texas Gas Transmission Corporation

IN THE PAST few years, much has been accomplished in automating main line compressor stations. Innovations range from the most sophisticated electronic control to a simple compact "black box" to consolidate engine starting controls.

Texas Gas Transmission Corporation is presently engaged in an expansion program incorporating some of the newest and most efficient angle type engines, including local automatic and local remote automatic engine start control panels.

In 1955, during the construction of a conventional main line station at Pineville, Louisiana, equipment was purchased by Texas Gas with an eye toward future automatic control of station throughput, the station's prime function, and also efficient, economical high torque engine operation.

The requirement for additional horsepower at this station in 1958 paved the way for the installation of our "Constant Torque-Automatic Throughput Control."

Application of this control requires certain characteristics in the engines and compressor cylinders:

1. High clearance and displacement compressor cylinders with a "flat" loading characteristic over a wide range of suction pressures.
2. Pneumatically operated head end or valve cap clearance volume unloaders if clearance pockets are required.
3. An engine capable of operating from approximately 80 to 100 percent of rated speed. Consideration also must be given to the effect of speed variation on engine-driven auxiliaries.

Why This System?

After skimming over the surface of this concept, let us regress a moment and consider why this was considered a worthwhile project.

Suppose the operator at any of our main line stations receives orders from the dispatcher to attain or hold a discharge pressure that within normal operating limits, determines the throughput of a station. He can by various means — speed, engine load, or number of engines on the line — attain or maintain the desired conditions if within the capabilities of his engines. Frequently, the means used to meet the pressures set for him involve operating an engine as much as 30 percent below rated torque, which causes an increase of as much as 20 percent in the specific fuel consumption. This practice leads to excessive fuel costs as well as poor engine performance, port carboning, erratic running, etc.

We have proved by test that, in the case of either 2-cycle or 4-cycle engines, speed can be varied to attain or maintain a desired discharge pressure while pockets are operated independently for full torque operation. The result is a constant fuel rate per bhp-hr.

Example of Constant Torque Operation

As an example of this type of constant torque operation, Fig. 1 shows an engine horsepower chart for fixed discharge pressures of 810 psig and 780 psig over a wide range of possible suction pressures, for a GMWC-6, 2000-hp engine. The pocket operation schedule indicates the discharge pressures at which pockets will open or close to maintain a high torque on the engine at all times. In addition, the control incorporates a suction override feature. As indicated by a rise in horsepower at 615 psig and 490 psig suction pressures in Fig. 1, this feature overrides discharge pressure control if the suction pressure reaches either of these two extremes. In the case of a 780-psig discharge pressure, one pocket would already have closed because of a drop in discharge pressure, leaving only one clearance pocket to be affected by the suction override control.

With this control, compressor cylinders will be loaded without regard to station throughput requirement. Speed then becomes the only variable with which throughput can be regulated. Engine speed, in turn, is controlled by the relationship of the actual station discharge to the required discharge pressure setting on a discharge pressure controller.

The discharge pressure controller with proportional band plus reset, sensing a deviation from the set discharge pressure, sends a pressure signal to the first engine governor, which will

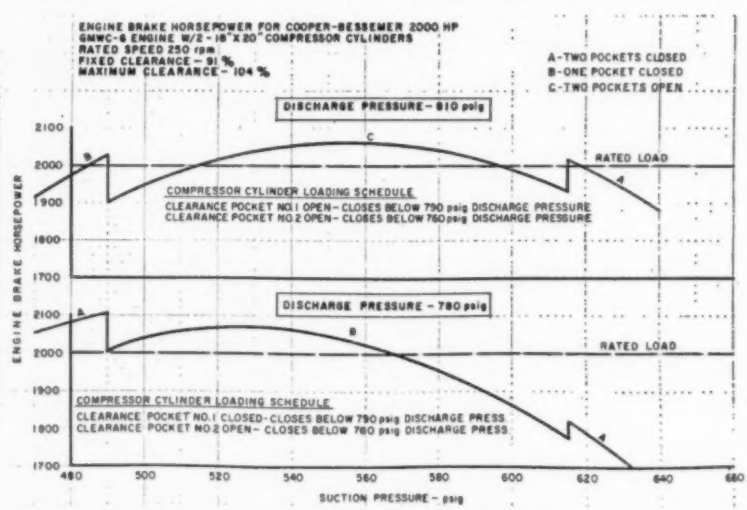


FIG. 1. Illustration of constant torque operation.

cause either an increase or decrease in engine speed within the present speed limits of the engine. If the set pressure is attained, no further speed changes will occur. When a greater change in discharge pressure is required, a second engine will begin a speed change after the first engine has reached a speed-setting limit. This stepped speed control will continue through all engines until the required discharge pressure is reached or all engines on the line have reached maximum or minimum speed setting.

When all engines on the line have reached a preset maximum or minimum speed setting without having attained the required discharge pressure, the operator will then increase or decrease the total station horsepower by putting engines on or taking engines off the line to fulfill the discharge pressure requirement. When all engines are operating at minimum speed it represents one less engine than when all engines are operating at full speed. If six engines are reduced to minimum speed but cannot reach the reduced discharge pressure called for, then five engines are used. Example: Six engines at 85 percent rated speed equals 5.1 engines, which we will assume to be 104 percent of required throughput. Five engines, four operating at 100 percent rated speed and one at 90 percent equals 100 percent of required throughput.

Six engines at 85 percent speed = 5.1 engines/1.04 = 4.9 engines required.

The cause of discharge pressure fluctuation to a station makes little difference to the controller. Be it clearance pocket operation or pressure variations upstream or downstream of the controlled station, the discharge pressure controller will react to maintain any reasonable discharge pressure.

We at Texas Gas felt that the desirable features of such a system easily could be nullified if the complexity of the controls was not kept to a minimum. With the cooperation and experience of the Electronic and Controls Division of the Cooper-Bessemer Corporation, a simple, compact, exclusively pneumatic control panel was built to perform the specified control functions. A picture of the panel is shown in Fig. 2.

Control Panel Operation

The top controller, PC-1 performs the automatic throughput control function and the two controllers, PC-2 and PC-3 below, control engine torque as a function of suction and discharge pressures. Suction and discharge pressure gages, as well as compressor load indicators, are mounted on the panel front.

FIG. 2. Control panel containing controllers, gages, pocket load indicators, and snap-acting pilot valves to regulate torque and speed for seven engines.

A schematic of the pneumatic circuit for engine speed and compressor pocket control is shown in Fig. 3. Indicated on each of the seven engines are both compressor torque control by head end pneumatic clearance pockets and speed control to each pneumatically operated governor. For clarity, a number of air supply lines have not been shown.

Each of the two-way, three-port, snap-acting pilot valves labeled PV-1, PV-2, etc., will open or close clearance pockets at a predetermined output pressure from controllers PC-2 and PC-3, which are in proportion to suction and discharge pressures respectively.

Pilot valve ports B and C are connected and port A is closed below the pressures shown under each valve in Fig. 3. At or above these pressures, ports A and C are connected and port B is closed.

To follow through our pneumatic circuit we must also establish that compressor clearance pockets will open to unload the cylinder when air pressure is admitted to the pocket diaphragm in the head end of each cylinder. Let me inject here that because we control two different types of engines, one 2000-hp engine and six 1500-hp engines, with two 18-in. by 20-in. and two 16-in. by 20-in. compressor cylinders, respectively, we cannot operate all pockets at identical pressures. Therefore, pilots PV-2, PV-6, and PV-5 control pocket No. 2, engines 1-6; pilots PV-2 and PV-3 control pocket No. 2, engine No. 7, and pilots PV-2, PV-1, and PV-4 control pocket No. 1 on all engines.

Starting at pilot valve PV-2 in Fig. 3, if the station suction pressure is over 615 psig (see Fig. 1) all pockets will be closed by venting all pocket pressure circuits through port A. Less than a 615-psig suction pressure will pass control air through ports B and C to port A pilot valve PV-1. A suction pressure above 490 psig (see Fig. 1) will connect ports C and A, PV-1 passing control air to pilot valve PV-4.

It is evident that the No. 1 clearance pocket on all engines can be opened only when the station suction pressure is between 490 psig and 615 psig, which will permit control air to pass through pilot valves PV-1 and PV-2 to pilot valve PV-4. Assuming we have a pressure between these two limits, pilot valve PV-4 will open all No. 1 pockets (ports C and A connected) above a discharge pressure of 760 psig or close all No. 1 pockets (ports C and B connected) below a discharge pressure of 760 psig.

The same type of control is exercised by other pilot valves on their respective clearance pockets, as evidenced by the clearance pocket schedules in Fig. 1. Control of any number of pockets or valve lifters based on suction and/or discharge pressure may be accomplished by similar combinations of pilot valves.

Control of station throughput by discharge pressure is accomplished by a proportional band plus reset controller PC-1, shown in Fig. 3. The 6 to 30 psig output from controller PC-1 is fed to all pneumatically operated engine governors through ratio relays RR-1 through 7. Each ratio relay reacts only to the pressure range indicated to send a 3 to 15 psig air signal to each engine governor. The pressure delay ratio relays cause the stepping control previously described.

In the near future we plan to add a

The Author

Olin P. Drake *is a senior staff engineer in the compressor department of Texas Gas Transmission Corporation, Owensboro, Kentucky. He joined the Texas Gas engineering staff in 1949 following graduation from New York University with a BSME. In his ten years with Texas Gas, Drake has worked in various phases of pipeline and compressor station construction, Federal Power Commission calculations, and pipeline and compressor station operational research and testing.*

circuit that will further improve service from the control system. This will cause an audible and/or visible signal to occur when the discharge pressure called for by a controller setting has not been reached and all engines on the line are at maximum or minimum speed. This signal will indicate the need for additional or fewer engines on the line to meet the required discharge pressure setting.

We have found the operating tolerance of our controls to be quite satisfactory. In the case of pocket operating pressures that are not critical, we find that each pilot valve operates consistently at plus or minus 2 psig of a preset pressure. With the infinite engine speed variation possible, our discharge pressure control is well within the 1 percent accuracy limits of station pressure gages.

Our experience with automatic throughput and torque control has been quite favorable. Our problems were minimized by the interest and cooperation shown by operating personnel at Pineville, Louisiana, station.

We look forward to years of increased engine efficiency at this our first controlled station and at new locations now in the planning and construction phase. ★ ★ ★

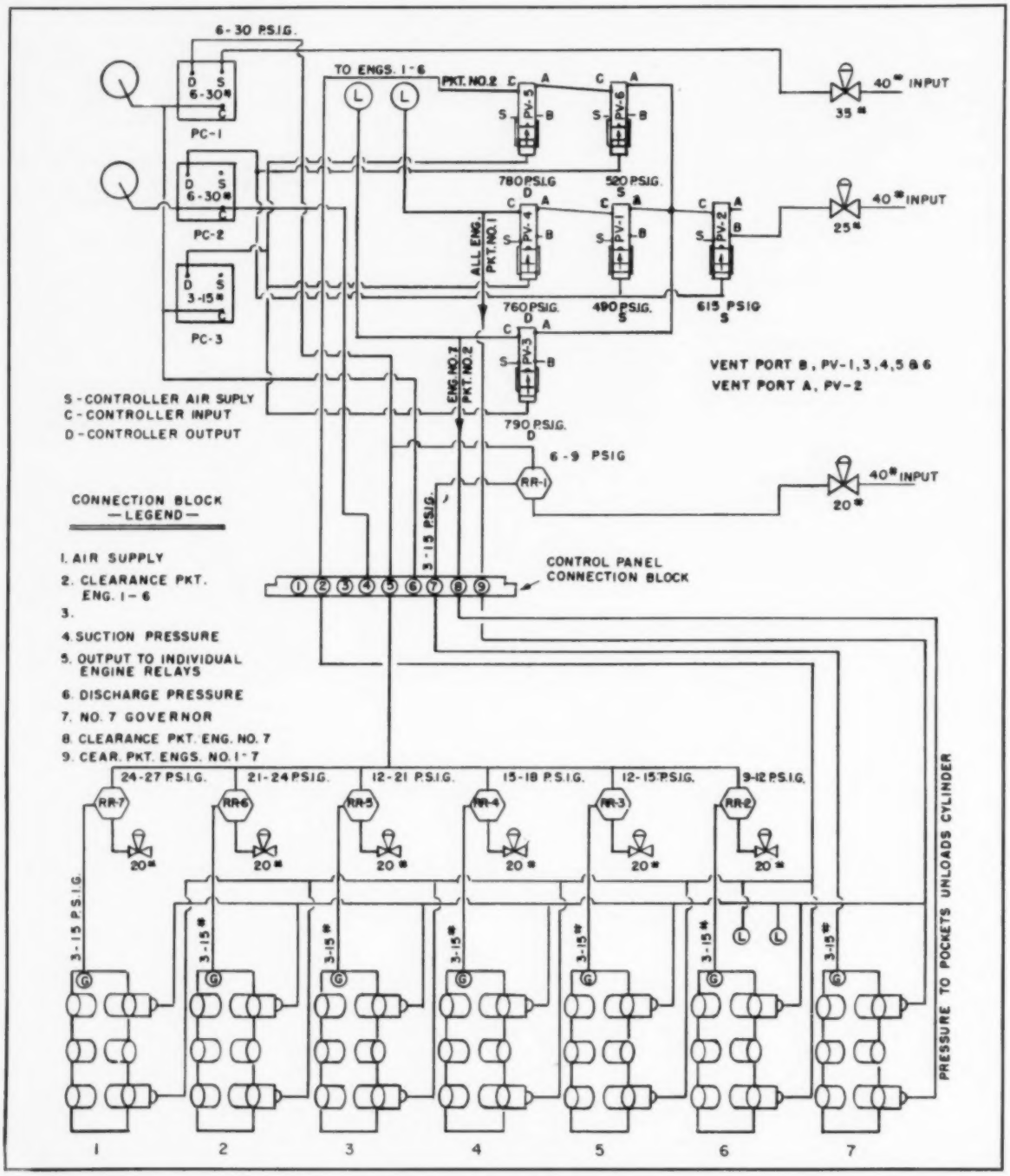


FIG. 3. Pneumatic circuit for engine speed and compressor pocket control.

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That decision you made a year ago on pipeline coatings is irrevocable now. It's in the ditch and only time will tell—time and the maintenance records.

Time *has* told on a lot of pipelines. And the story is that there's no more proven enamel than Bitumastic *coal-tar* enamel. Over thirty years of use in pipelining have documented coal tar's superior moisture resistance and electrical insulating properties underground.

Coating cost is but a minute fraction of total pipeline investment: can you afford to gamble your pipeline investment on unproved products? Koppers Company, Inc., Tar Products Division, Pittsburgh 19, Pennsylvania. *In Canada:* Koppers Products, Ltd., Toronto.

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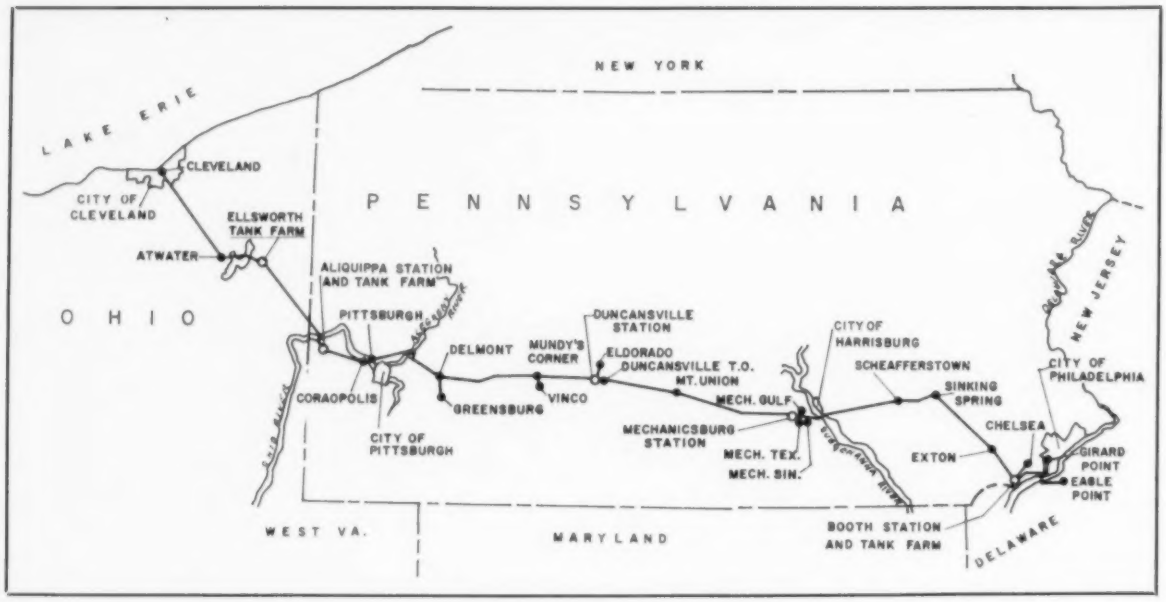


Laurel Pipe Line System.

Design Features of the Laurel Pipe Line System

Automatic and central controls reduce attendance cost to a minimum

James F. Stephenson
Marlan G. Jordan
Laurel Pipe Line Company

THE LAUREL PIPE LINE System is a petroleum products pipeline extending from the Philadelphia, Pennsylvania, area to Cleveland, Ohio. Supply for the system is taken from refineries into Booth station and tank farm for further distribution. The 16 grades of product are delivered from refineries to Booth storage into nine gasoline tanks and eight distillate tanks.

Products received at Booth are sized into separate batches or blocks in accordance with the demand created by the 15 sales terminals and two other carriers in the State of Pennsylvania, and four sales terminals and one other carrier in Ohio.

Products are pumped from a manned automatic station at Booth through 107 miles of 24-in. pipeline to a manned automatic booster station at Mechanicsburg, Pennsylvania. From Mechanicsburg station the product is pumped through 77 miles of 20-in. line to an unattended remotely controlled booster station at Duncansville, Pennsylvania. Products are further boosted by Duncansville station through 114 miles of 18-in. line into working tanks at a manned station at Aliquippa, Pennsylvania.

Identity of shippers' products is maintained at Aliquippa. Products accumulated at Aliquippa are rescheduled to supply four sales terminals located at Ellsworth, Atwater, and Cleveland, and to another carrier at Ellsworth for transportation to destination. The 14-in. line between Aliquippa and Cleveland is 107 miles long.

Communications System

Objectives of communications for the system are to provide reliable talking circuits between any two points on the system and to provide good quality circuits for telemetering and supervisory control of the pipeline.

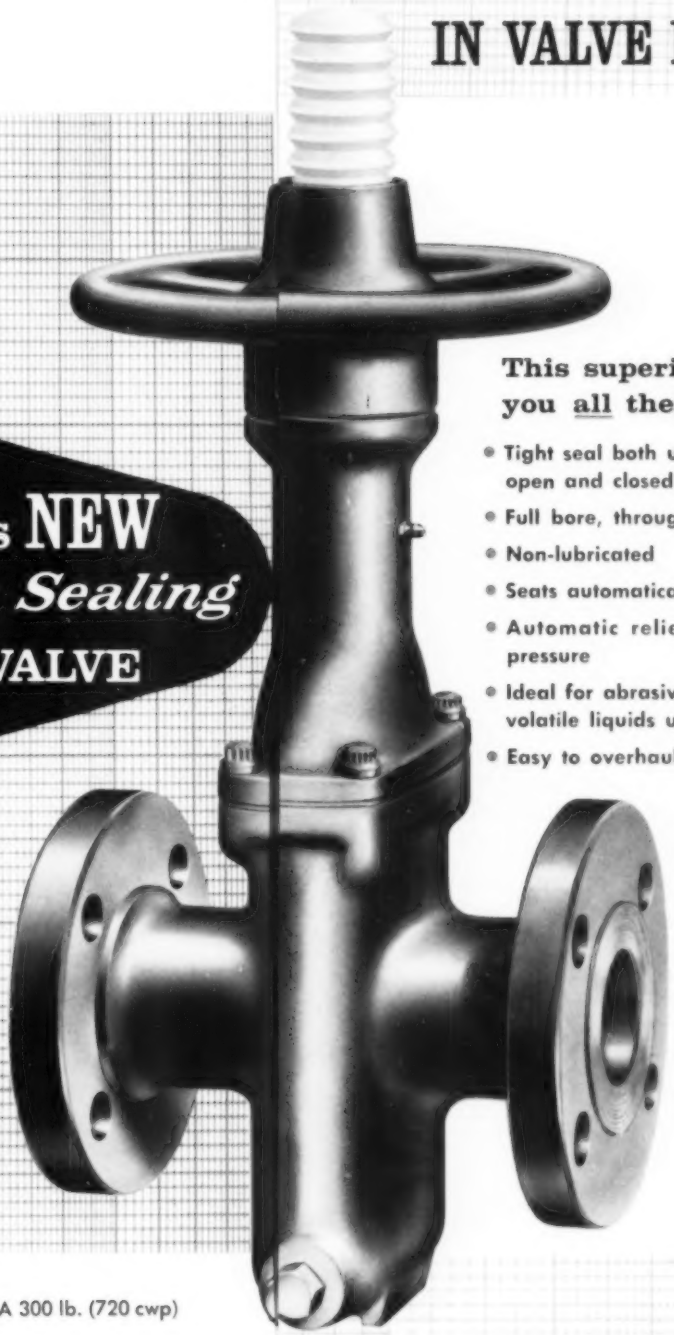
Laurel Pipe Line Company is joint owner of a microwave system between Philadelphia and Aliquippa. Leased facilities are used from Aliquippa to Cleveland, Ohio. For maintenance and operation purposes a VHF mobile radio system is provided with base control stations at Camp Hill, Mechanicsburg, and Coraopolis, Pennsylvania. Through the use of the channel on the microwave system used for VHF mobile radio, personnel may be contacted anywhere on the pipeline system. Six channels east of Camp Hill, and 10 channels west of Camp Hill are currently in service.

Dispatched From Camp Hill

Dispatch board for the system and the central console for Duncansville remotely operated booster station are situated in the Camp Hill office, near Harrisburg, Pennsylvania, which is the center of operations for the system. All intelligence indicated on the dispatch board is logged on an automatic typewriter at any predetermined time

Presented before Annual Pipeline Conference of American Petroleum Institute's Division of Transportation, Pittsburgh, Pennsylvania, May 13-15, 1959.

NOW! THE BOLD ADVANCE IN VALVE DESIGN



W-K-M's NEW *Pressure Sealing* GATE VALVE

This superior valve gives you all these advantages:

- Tight seal both up and downstream in open and closed position
- Full bore, through-conduit
- Non-lubricated
- Seats automatically adjust for wear
- Automatic relief of excessive body pressure
- Ideal for abrasive ladings, light gases, volatile liquids up to 250° F.
- Easy to overhaul on the line

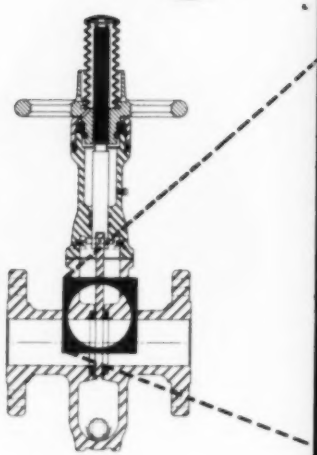
ASA 150 lb. (275 cwp) and ASA 300 lb. (720 cwp)

ANOTHER OUTSTANDING PRODUCT OF **W-K-M's** *Creative Engineering*

Floating

Combination indicator and stem protector. A neoprene rubber bellows compounded to a bright yellow color for long-range visibility—extends above the handwheel when the valve is open; retracts into the handwheel when the valve is closed. It also protects the stem threads from dirt and corrosion.

The stem is heat-treated, hardened stainless steel, with double lead Acme threads for fast operation.



Anti-friction bearings support the operation of the stem nut and handwheel. This feature contributes to easier operation and longer, trouble-free life.

A grease fitting is provided in the bonnet to allow lubrication of the stem threads and bearings.

"O" rings are used for stem packing. They provide an ideal seal and eliminate repacking procedure required with conventional valves.

The bonnet-body connection is a rigid bolted construction with a rubber primary seal and metal-to-metal secondary seal. This seal eliminates the high bolt loads required by conventional bolted connections.

The gate is made of steel, hard-chrome-plated for protection against wear and corrosion.

The floating seats are unique in design. Each seat consists of two kinds of rubber, formulated to W-K-M's specifications, molded to a hardened steel insert. There is a full bore opening, the same diameter as the port, through the insert.

Soft rubber, for sealing, is on the back side of each seat. Tougher, abrasive-resistant rubber, to resist wear, is on the front or gate side. The steel insert is ringed with holes. Pressure forces the soft rubber through these holes, reinforcing the tough rubber and compensating for any wear.

The body and bonnet are steel.

The port is round, the same diameter as the I. D. of the pipe.

Through-conduit construction permits maximum flow, minimum turbulence and pressure drop.

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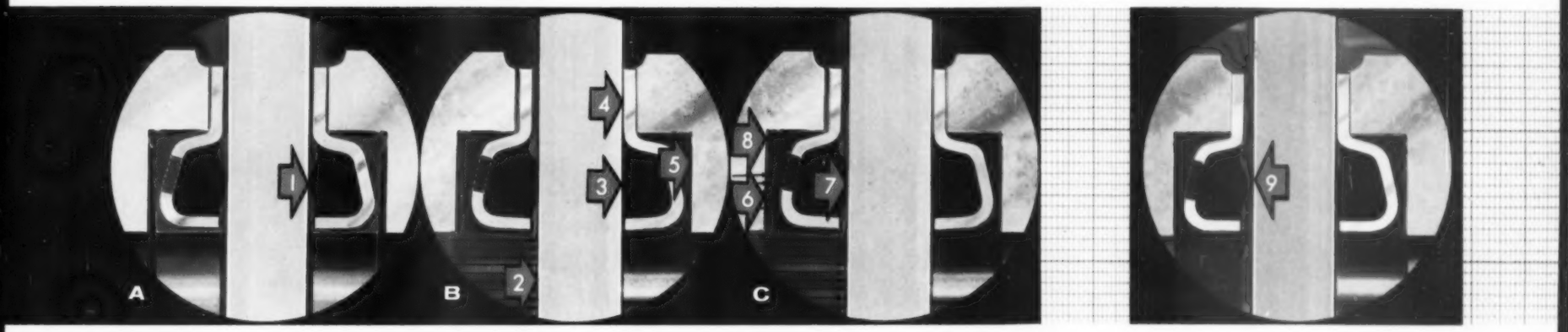
Seats Give Perfect Seal



Line Pressure Seals the Seats!

Illustration A shows the gate in the closed position as it forms a primary seal (1) with the raised ring of tough, firm rubber on the face of each seat.

As line pressure (2) is applied to the valve in Illustration B, the gate is forced against the rubber ring on the downstream seat (3) and compresses it until the gate rests against the hardened steel insert (4). This provides a tight seal between the gate and the rubber on the face of the seat, and a secondary metal-to-metal seal. The action also forces the soft rubber on the back of the seat tightly into its recess (5) and prevents any downstream flow at this point. This double action provides a bubble-tight downstream seal.

The upstream seal shown in Illustration C is caused by line pressure forcing its way into the seat recess behind the upstream seat (6), thereby moving the seat against the gate (7). This pressure is sufficient to achieve a positive seal between the gate and the ring of tough rubber on the face of the seat. At the same time, the raised rim of soft rubber on the back of the seat forms a tight seal with the seat recess (8).

These double-action floating seats provide tight, positive seals—both upstream and downstream.

W-K-M's NEW *Pressure Sealing* GATE VALVE

Two-Way Valve

W-K-M's Pressure Sealing Gate Valve is a two-way valve. It may be installed with the pressure on either side. This valve is especially well suited for block and bleed service since it seals positively both upstream and downstream. The body may be bled of pressure with the gate in either the fully open or fully closed position.

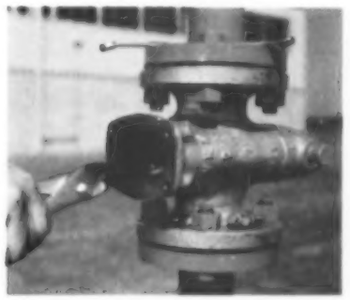
Full Bore, Through-conduit

The full bore, through-conduit gate construction provides a perfectly smooth bore through the valve, eliminating pockets or cavities in which foreign matter might accumulate. Result: perfectly smooth flow with no more turbulence or pressure drop than through an equal length of pipe.

IMPORTANT SAFETY FEATURE:

Automatic Relief of Excessive Body Pressure

This valve has been designed to automatically relieve excessive body pressure caused by thermal expansion. The excess pressure forces the upstream seat away from the gate (9), allowing it to bleed into the line.



Change Seats in Minutes

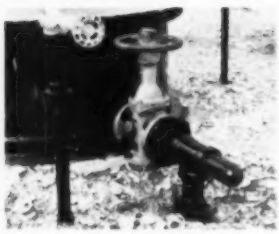
...on the Line!

Construction of the valve is so strong and materials are so durable that users so far have found maintenance unnecessary. But in time every material wears, and some maintenance is required.

When that time comes you can change the seats in W-K-M's Pressure Sealing Gate Valve (2" through 12") in 15 to 30 minutes *on the line*. The only tools needed are a wrench to loosen the body bolts, and a pair of pliers.

ONE OF THE MOST VERSATILE VALVES EVER PRODUCED

Natural Gas Transmission



Crude Oil

Butane/Propane

Natural Gas Distribution

Proved in the Field!

This new valve is extremely versatile. It's designed for pressures up to 720 psi (cwp) and temperatures up to 250° F. Here are only a few of the services in which it will perform efficiently and economically.

Gasoline
Abrasive Slurries
Alkaline Solutions
Solvents
Nitric Acid
Sulphuric Acid
Methyl, Ethyl, Butyl, Propyl Alcohols
Ethylene Glycol
Butyl Stearate
Kerosene
Naphtha
Stoddard's Solvent
Carbon Tetrachloride
Water
Air

SPECIFICATIONS

Valve Size	2"		3"		4"		6"		8"		10"		12" *	
ASA Rating (lbs.)	150	300	150	300	150	300	150	300	150	300	150	300	150	300
Screw End	X	X	X											
Weld End	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Weld by Flange	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Flanged End	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Gear Operated							X	X	X	X	X	X	X	X

*14" and larger available on request

AVAILABLE NOW at competitive prices from your supplier.

For complete information about W-K-M's new Pressure Sealing Gate Valve . . .

WRITE FOR CATALOG 1200

W-K-M Division of ACF Industries, Incorporated P. O. Box 2117 Houston 1, Texas

W-K-M SERVING INDUSTRY 40 YEARS

5901

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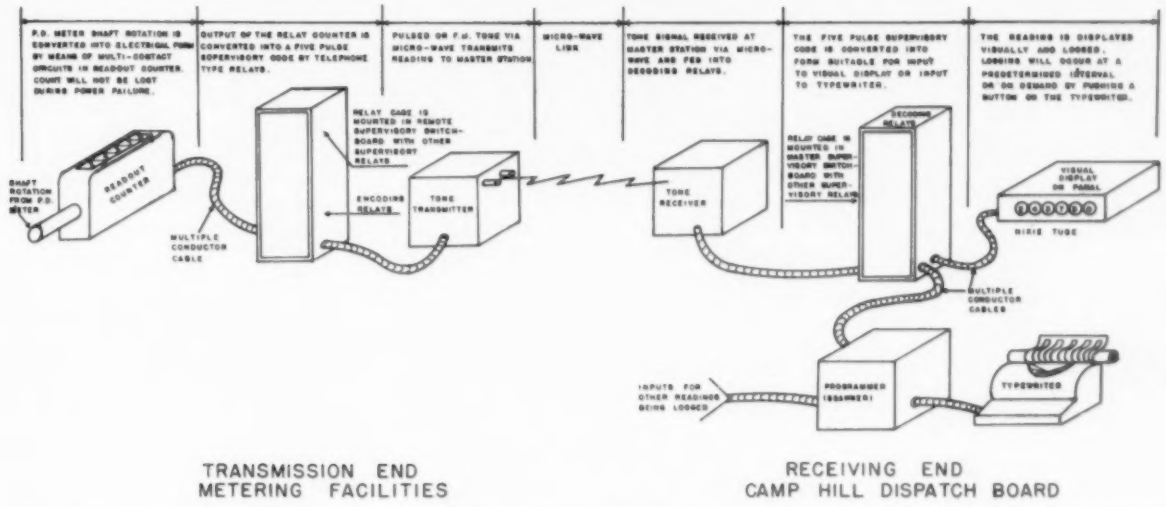

P.D. METER SHAFT ROTATION IS CONVERTED INTO ELECTRICAL FORM BY MEANS OF MULTI-CONTACT CIRCUITS IN READOUT COUNTER. COUNT WILL NOT BE LOST DURING POWER FAILURE.
OUTPUT OF THE RELAY COUNTER IS CONVERTED INTO A FIVE PULSE SUPERVISORY CODE BY TELEPHONE TYPE RELAYS.
PULSED OR F.d. TONE VIA MICRO-WAVE TRANSMITS READING TO MASTER STATION.
MICRO-WAVE LINK
TONE SIGNAL RECEIVED AT MASTER STATION VIA MICRO-WAVE AND FED INTO DECODING RELAYS.
THE FIVE PULSE SUPERVISORY CODE IS CONVERTED INTO FORM SUITABLE FOR INPUT TO VISUAL DISPLAY OR INPUT TO TYPEWRITER.
THE READING IS DISPLAYED VISUALLY AND LOGGED. LOGGING WILL OCCUR AT A PREDETERMINED INTERVAL OR ON DEMAND BY PUSHING A BUTTON ON THE TYPEWRITER.
SHAFT ROTATION FROM P.D. METER
READOUT COUNTER
MULTIPLE CONDUCTOR CABLE
RELAY CASE IS MOUNTED IN REMOTE SUPERVISORY SWITCH-BOARD WITH OTHER SUPERVISORY RELAYS
ENCODING RELAYS
TONE TRANSMITTER
TONE RECEIVER
DECODING RELAYS
RELAY CASE IS MOUNTED IN MASTER SUPERVISORY SWITCH-BOARD WITH OTHER SUPERVISORY RELAYS
VISUAL DISPLAY ON PANEL
NIXIE TUBE
MULTIPLE CONDUCTOR CABLES
INPUTS FOR OTHER READINGS BEING LOGGED
PROGRAMMER (ASSEMBLY)
TYPEWRITER
TRANSMISSION END METERING FACILITIES
RECEIVING END CAMP HILL DISPATCH BOARD

Digital telemetering system for positive displacement meter.

interval, or can be logged upon demand.

Intelligence received from the three refinery delivery points includes positive displacement meter readings and line pressure indicated continuously, and flow rates in barrels per hour are recorded continuously.

Intelligence received from the 18 take-off metering stations includes positive displacement meter readings and main line pressure, indicated continuously; product analyzer or batch detector and flow rate recorded continuously. From the dispatch board the dispatcher has control and indication of take off, and main line block valves and set point control of flow rates.

When notified that a meter station is in readiness to receive a delivery, the dispatcher can determine the location of the product to be delivered by means of a batch detector. If the delivery is to be a stripping delivery he opens the take-off valve. As the take-off valve opens, from the indication of flow rate and pressure, he can then use the set point control to raise or lower the flow rate to the selected delivery rate. The delivery rate can be changed from time to time to adjust to changing line hydraulic conditions.

Through the use of this set point control at the 18 metering stations, it is felt that the maximum line throughput efficiency can be attained at minimum power cost. From the positive displacement meter reading displayed by Nixie tubes on the board the dispatcher can determine when the predetermined delivery is completed. The dispatcher can then close the take-off valve and the deliveryman can pick up the run ticket at his convenience.

ABOUT THE AUTHORS

J. F. Stephenson

M. G. Jordan

James F. Stephenson, station construction superintendent, is an electrical engineering graduate of Texas A&M College. He was first employed by Gulf Refining Company for summer work while attending college, and after serving as a major in the Army Corps of Engineers during World War II, returned to Gulf as a corrosion engineer. Since that time he has been an electrical engineer, and in 1957 was assigned to the Laurel Project.

Marlan G. Jordan, chief engineer, received a BS degree in civil engineering from Southern Methodist University in 1950. After serving a short hitch as a laborer with Gulf Refining Company he was transferred to Fort Worth as a civil engineer. In 1952 he was made a design engineer with headquarters in Houston. He was assigned to Pittsburgh as staff engineer for the coordinator of pipelines in 1955, and assumed his present position in 1958.

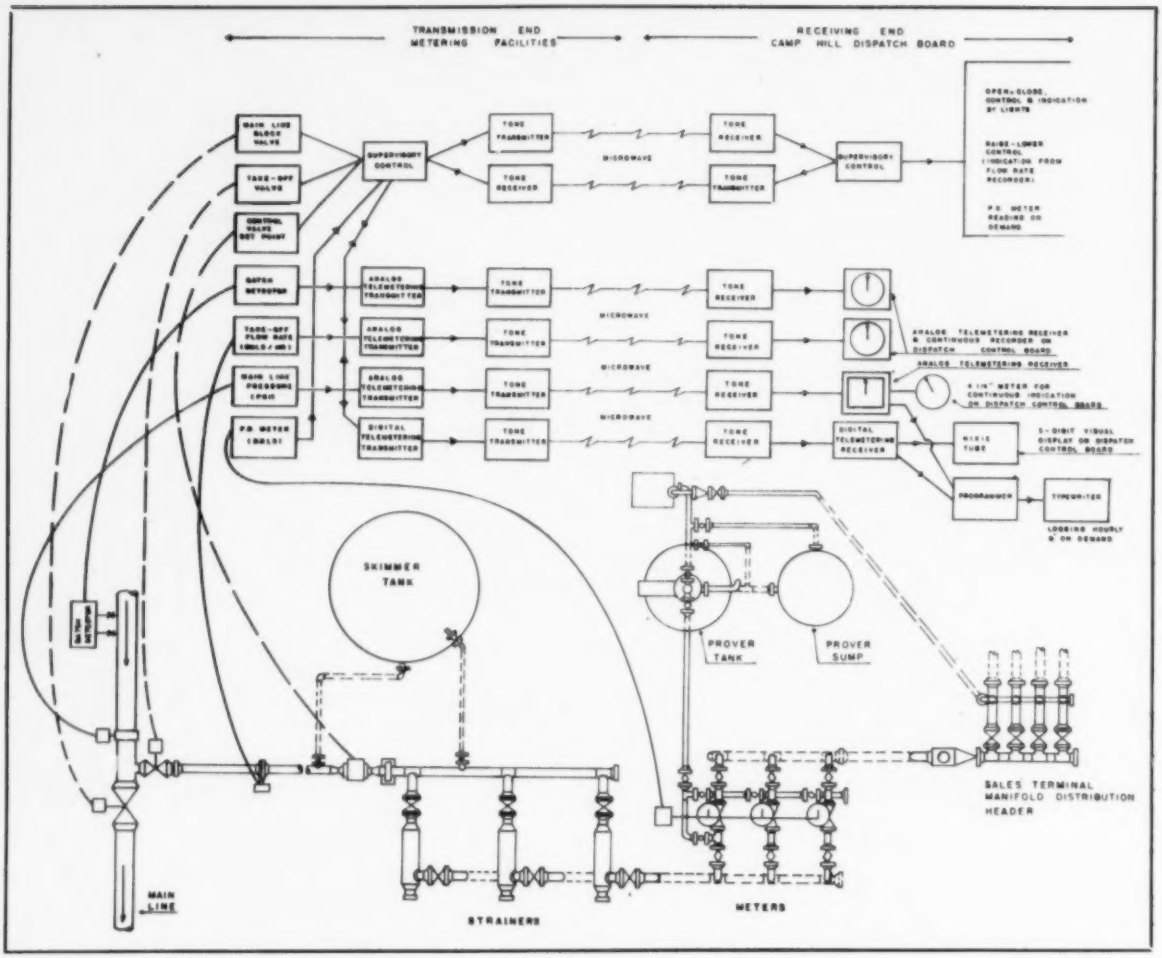
Telemetering System

The digital telemetering system for the positive displacement meters is accomplished by a readout counter mechanically coupled to the meter totalizer. The totalizer rotation is converted into electrical form by means of multi-contact circuits and will not be lost during a power outage. Output of this readout counter is fed into encoding relays where it is converted into five pulse supervisory code. This pulse code is fed into the tone transmitter via microwave to the master station at the Camp Hill office. The pulse code from the tone receiver is fed into the decoding relays where it is converted in suitable form for input to the visual display and to the typewriter.

Flow rates, pressures, and batch detectors are telemetered by the analog or time duration method. These analog telemetering values are converted by a Giannini disc on the dispatch board to digital figures and fed into the programmer for use in the logging system.

Intelligence received from the Duncansville remotely controlled booster station includes station suction and case pressure, outbound line pressure, and flow rate, recorded continuously. Light type indication is of main and unit circuit breakers, power company voltage, unit incomplete sequence, position of station valves, low suction and high case pressure, high station discharge pressure, high outbound line pressure, high and low station flows, and high strainer differential.

These functions could be a transient condition and from the lights indication on the Duncansville console the dispatcher may determine whether



Telemetering and supervisory control functions at metering facilities.

the trouble is a temporary condition. A channel test pushbutton, channel failure light, ready and reset pushbutton, and system check pushbutton are also provided for test purposes.

In the event of a station or unit shut-down the station console has lights indicating either mechanical or electrical trouble. A mechanical trouble light indicates that the shut-down was caused by excessive unit vibration, high pump or motor bearing temperature, pump seal failure, and pump case temperature. A mechanical trouble light without a shut-down would indicate high sump level or low instrument air. An electrical trouble light would entail single phase, station overcurrent, phase balance, high unit motor winding temperature, and unit motor overcurrent. An electrical trouble light without a shut-down would indicate low tripping battery voltage.

From the dispatching board and console the dispatcher has control of nine station valves, set point control of flow rate, suction and outbound pressure. An emergency shut-down pushbutton is provided to completely de-energize the station.

Intelligence received from Booth station includes incoming flow rate on both refinery feeder lines recorded; station suction and outbound line pressures indicated continuously; outbound positive displacement meter readings indicated continuously, and outbound flow rate recorded.

From Mechanicsburg station telemetered intelligence includes station suction and outbound line pressures indicated continuously, and the flow rate is recorded.

Intelligence from Aliquippa station received at the Camp Hill office includes incoming and outbound flow rates recorded on a circular chart; station suction; outbound line and two hill pressures are indicated by instruments. The positive displacement meter readings are displayed on the Nixie tubes.

The dispatch board and remote station control console are so designed that a green light indicates normal operation and a red light indicates off-normal or trouble. Any time the dispatcher sees a red light he can investigate immediately and take action to correct the condition causing the off-normal operation. Valve indication is by an amber light indicating an open valve and a blue light indicating a closed valve. When both lights are illuminated it indicates that the valve is in the interim position.

Control at Metering Stations

At metering stations the flow rate is controlled by an electrically driven hydraulic controller. The starting circuit of this control valve is governed by the limit switches in the take-off valve. When the take-off valve leaves the fully closed position the hydraulic pump motor starts and continues to run until the take-off valve returns to the fully closed position. If a pressure exceeding the working pressure of the meters is reached a high pressure switch closes the take-off valve. Indication of high

meter bank pressure is indicated by a red light on the remote supervisory cabinet.

Meter totalizers are equipped with a set stop or preset switch that can be set for the amount of the delivery and when this predetermined quantity has been delivered the take-off valve will close.

On meter banks, where necessary, electrical counter shifters have been installed so that the deliveryman can shift the counters from the distribution manifold when a switch is made from one product to another.

A continuous sampler is installed at all metering stations so that a composite sample of the product delivered is taken for future reference.

Meters are manifolded so that they may be proved volumetrically or by the master meter method. Electrical counter shifters are installed to aid in the master meter proving method.

Standby emergency generators at all locations automatically start when commercial power fails. These emergency generators supply power for local and remote operations and for communications.

Automatic Sequence Operation

Main line pumping stations are automatic-sequence operated, with standard protection devices, including pump and motor bearing high temperature, high pump case temperature, low suction pressure, high pump case pressure, pump seal failure, excessive vibration, motor overcurrent, and high motor winding temperature.

All pressures indicated on the station control consoles are electrically transmitted signals from SR-4 strain gages. The control rooms are of the pressurized type, housing indoor high voltage switchgear, motor control center, and other associated equipment.

Tank farms are equipped with pulse code remote reading tank gaging equipment.

Automatic standby generators at all stations supply emergency power for operation of critical valving, lighting, and power for communications equipment.

The booster pumps at Booth station may be started and stopped manually or automatically. When the booster pump control is in the automatic position and the station suction pressure falls below 25 psi, the starting sequence of booster pump No. 1 is energized. If the pressure output of booster pump No. 1 is not sufficient to meet the desired pressure, or if at any time while booster pump No. 1 is on the line the pressure falls below this value, then the starting sequence of booster pump No. 2 is energized. When the station suction pressure exceeds 65 psi the booster pumps are shut down in a manner reversed to that described for starting.

Hydraulic Gradient Maintained

Due to the hydraulic characteristics of the system west of Duncansville station, a back pressure valve is located on the incoming line at Aliquippa station, which maintains a hydraulic gradient above Laurel or Crescent Mountain, the controlling high points between Duncansville and Aliquippa stations. To accomplish this a pressure teletax transmitter situated near the summit of these mountains will control the back pressure at Aliquippa station to hold the hydraulic gradient above 25 psi at these control points. If full stream deliveries are made to either Pittsburgh or Coraopolis metering stations, the electro-hydraulic control valves at these metering facilities are controlled in the same manner as the back pressure valve at Aliquippa station.

From the foregoing description of the Laurel Pipe Line System it can be concluded that the automatic and central control features were incorporated in the system to reduce attendance cost to a minimum. We are indebted to the designers of the system, to the pipeline industry, and to the equipment manufacturers whose experience and know-how contributed to the overall design problem. * * *

Pipeline Right-of-Way Seeded from Helicopter

AS ONE MORE EXAMPLE of the gas industry in the air age, Pacific Lighting Gas Supply Company of Los Angeles, recently seeded from the air more than 35 miles of a 100-ft-wide pipeline construction strip.

The right-of-way in question was the most mountainous section of an 81.7-mile stretch traversed by PLGS's new 34-in. diam line from North Coles Levee in San Joaquin Valley to Quigley metering station in Newhall, just outside of Los Angeles. Cost of constructing the line was $14,290,000.

The pipeline also will be patrolled once weekly by air, with the aerial check supplemented by a once-a-month ground inspection of the line. PLGS initiated use of aerial patrol of pipelines four year ago.

The new line has a capacity of 546,000,000 cu ft, with an upstream pressure of 750 psi and 465 psi terminal pressure at the Quigley metering station. The line was designed to operate at 750 psi maximum pressure throughout its length for line-pack storage.

Seeding of the right-of-way was to assist soil stabilization and for protection against erosion due to wind and rain.

Engineers decided on the aerial seeding for two reasons: economy and speed. An estimate of on-the-ground seeding showed a potential cost of $1000 per mile, while the air drop runs between $450 and $500 per mile. Had it been done on the ground, the seeding would have taken an estimated two to two and one-half months. The air drop took three weeks, with the helicopter — owned by National Helicopter Company of Van Nuys — actually in use for only 96 hours. At that the job was shut down for several days due to adverse wind conditions.

Despite the fact that southern California is not known for being particularly rough pipelining country, the PLGS line of necessity had to be laid along a mountainous route.

The strip was seeded with a mixture of brome and rye grass — four tons in all. The job also required 72 tons of fertilizer — enough to take care of more than 145,000 good-size front lawns. The "chopper' carried a 500-lb load of seed or fertilizer each trip.

Supplies of seed and fertilizer were trucked to two locations along the right-of-way and then loaded aboard two funnel-shapped dispensers attached to the helicopter. Seed and fertilizer were dropped from an elevation of about 25 ft in separate flights along the route.

Following the aerial seeding, the right-of-way was harrowed to assure satisfactory bedding of the seed and maximum germination.

PART 1

Scheduling and Dispatching Crude Oil and Refined Products

Fred Ashford, Jr.
Division Manager, Oil Traffic Division
The Texas Pipe Line Company
Houston, Texas

Nothing is more vital to the success of pipeline transportation than effective and efficient dispatching. The movement of crude oil and refined products from their source to destination seems to be a simple process, but it is complicated by regulations, restrictions, and segregation of various crudes and refined products. Through thousands of miles of undeground pipe, rivers of crude oil and refined products flow, their direction and movement guided and controlled by orders issued by dispatchers and carried out by field personnel. For 24 hours each day, seven days a week, dispatchers similar to train dispatchers receive and transmit orders affecting the movement of hundreds of thousands of barrels of petroleum and petroleum products.

Dispatching in a major pipeline is an involved process that must be carried out with clock-like precision and demanding exactitude. The dispatching department must insure that all shippers' crude oil and products are moved through the pipeline according to the shippers' specific instructions. This means that gathered oil must be moved to trunk stations, and oil and products received and delivered to connecting carriers, refineries, and terminals. All of these movements must be carried out so as to maintain the quality of crude oil or refined products according to the shippers' instructions. To accomplish this, all stations' pumpings and line pressure and all tank switches must be controlled by the dispatching department.

Now let us consider the types of organizations that are used in the pipeline industry to handle the movement of crude oil and products.

ORGANIZATION

Centralized versus decentralized. There are basically two types of organizations that may be used to handle the scheduling and dispatching of crude oil and products through pipelines. First is the centralized type and, secondly, there is the decentralized type of organization. Each type is briefly described below.

Centralized. This type of organization consists of the manager, chief dispatcher, and all dispatching and clerical personnel being located in the same central office, usually the home office. All information from the various shippers is received in the central office, and consolidated monthly schedules are given to the chief dispatcher. The chief dispatcher and his assistants then project monthly schedules and issue daily orders and instructions to the various pump stations and terminals. In this type of organization, control of all movements through the various pipelines is handled from one central location. Sufficient dispatchers are maintained on duty in the central office around the clock to control movements through the pipelines.

Decentralized. This type organization requires that the home office have a group, usually consisting of a manager, supervisor of schedules, and several coordinators, whose prime responsibility is to receive all monthly schedules from the respective shippers, consolidate them and transmit these monthly quotas to each of the respective areas or field chief dispatchers.

The home office group has the responsibility of seeing that a tariff is in effect on each movement or will be issued, allocating space to various shippers and checking monthly quotas with connecting carriers and refineries.

Each area office has a chief dispatcher, assistant chief dispatcher, and sufficient dispatchers on duty around the clock to control the lines in each area.

Advantages and disadvantages of each type of organization. One of the main advantages of a centralized organization is a saving in personnel. It is possible to schedule and dispatch a greater number of lines from a central location with fewer people than is possible with a decentralized organization. This is true because the work load per employee can be better distributed and fewer relief personnel are required for the various jobs. Another

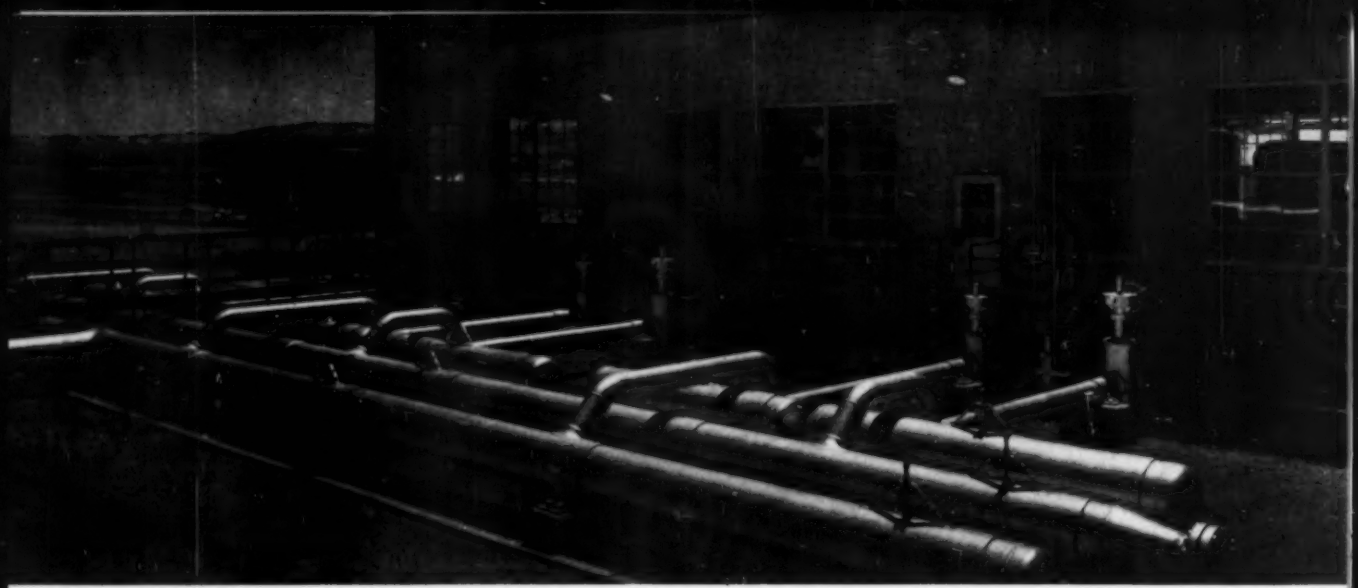
Fred Ashford, Jr., entered Texas A&M College in 1938 and was a student there until he entered the armed services in 1943. He was a captain in the Engineer Corps, U. S. Army, from 1943 to 1946. Graduated from Texas A&M with a bachelor of science degree in mechanical engineering in 1947. Entered employ of The Texas Pipe Line Company as a junior mechanical engineer in June 1947. A year later, in June 1948, he was made a mechanical engineer, and in February 1950 a field engineer. He became assistant to the division manager, Oil Traffic Division, in February 1951, and assistant division manager of the Oil Traffic Division in October 1952. Was appointed division manager in October 1953, which position he now holds.

Adjust these clutches ***ONCE*** *...and they'll stay!*

On Bucyrus-Erie 22-B Hi-WALKERS, the clutches automatically compensate for temperature changes throughout the day. The operator doesn't have to stop three or four times to adjust them up so they'll hold. And next morning he'll start right in again and the clutches will be even and firm.

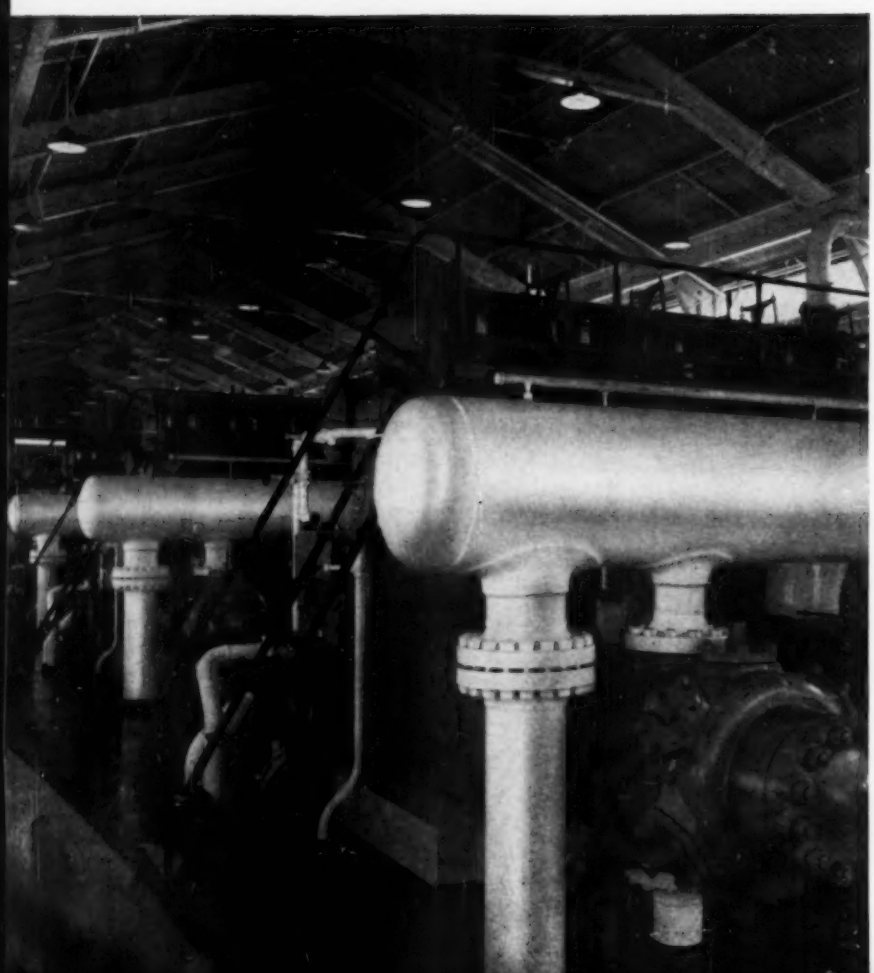
All main shaft and swing clutches on the 22-B Hi-WALKER are identical and their parts interchangeable. You don't need to carry along an expensive parts stock . . . one set of bands is your reserve.

Hi-WALKERS were specifically designed for pipelining. Get *all* the facts from your Bucyrus-Erie distributor, or write Bucyrus-Erie Company, South Milwaukee, Wisconsin, Dept. 35EB.



Station No. 7, at Kemmerer, Wyoming, rated at 5,060 hp, is 7,325 ft above sea level. Mayari R suction and discharge headers and pulsation dampeners are in the foreground.

Bethlehem Compressor Station Stations on the



The Pacific Northwest Pipeline

ranks with the most challenging of all pipeline projects—in total length, in size of pipe, in difficulty of the terrain, in severity of weather encountered during construction, and in the speed with which the job was completed. The remarkable success of the planners and constructors in overcoming obstacles is well-known to all pipeliners.

The 1,487-mile main line (26-in. OD) is unusual in that it is supplied at both ends, as well as at various intermediate points. Its southern terminus is at Ignacio, Colorado, in the San Juan Basin. Its northern terminus is at Sumas, on the Canadian border, where it ties in with a line from the Peace river fields. Gas is also delivered from the Piceance Creek and Rangely fields in Colorado, and Wyoming's Big Piney. Laterals bring total length of the line to well over 2,500 miles.

Fish Engineering Corporation handled all of the design, engineering, and station layout work, while Fish Northwest Constructors, Inc., were responsible for construction of the stations as direct agents for the owner, Pacific Northwest Pipeline Corporation.

This is Compressor Station No. 1 at Ignacio, Colorado, with 22-in. OD Mayari R suction and discharge bottles in evidence. Largest station on the system, its seven 2,000-hp units discharge gas to the line at 800 psi.

IN NEW JERSEY—36-in. OD Bethlehem line pipe being installed for a major transmission line. Numerous pipeline companies are already considering the economies of 42-in. pipe now available from Bethlehem.

Pipe Was Used at All Thirteen Pacific Northwest Pipeline

THERE are thirteen compressor stations, totalling 82,780 horsepower, along the 1,487-mile main line of the Pacific Northwest Pipeline. For these vital installations the Fish Engineering Corporation specified Bethlehem's Mayari R compressor station pipe—*exclusively*. It was used in 22-in. and 26-in. sizes for suction and discharge lines, headers, and bottles, and for pulsation dampeners.

Why? Because Mayari R high-strength, low-alloy steel is extremely strong (yield point, 50,000 psi min) and ductile (22 pct min elongation in 2 in.). It's highly recommended for applications subject to high pressures, pulsation, and vibration. And it's readily weldable, too.

Mayari R pipe is available in diameters from 18 in. up. It does not require heat treatment. Bethlehem supplies Mayari R plate to fabricators of elbows, tees, flanges, and other fittings.

Line Pipe to 42 in. OD. At Steelton, Pa., we produce API pipe, electric-fusion-welded and hydraulically expanded, from 18-in. to 42-in. OD, with walls to ¾ in. in all diameters. Electric resistance-weld pipe from 5⁹⁄₁₆ in. to 16 in. OD, and continuous buttweld pipe from ½-in. to 4-in. nominal, are produced to standard API line pipe specifications on our Sparrows Point, Md., pipe mills.

For more information about Bethlehem line and compressor station pipe, please contact the Bethlehem sales office nearest you. Ask for a copy of our new publication, Booklet 519, containing useful design tables concerning sizes 18 in. to 42 in., inclusive.

IN CALIFORNIA—Lines of Beth-Co-Weld pipe carry product from 24 wells to an automatic trap farm. Many miles of this reliable line pipe are used each year by the oil and gas industries.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

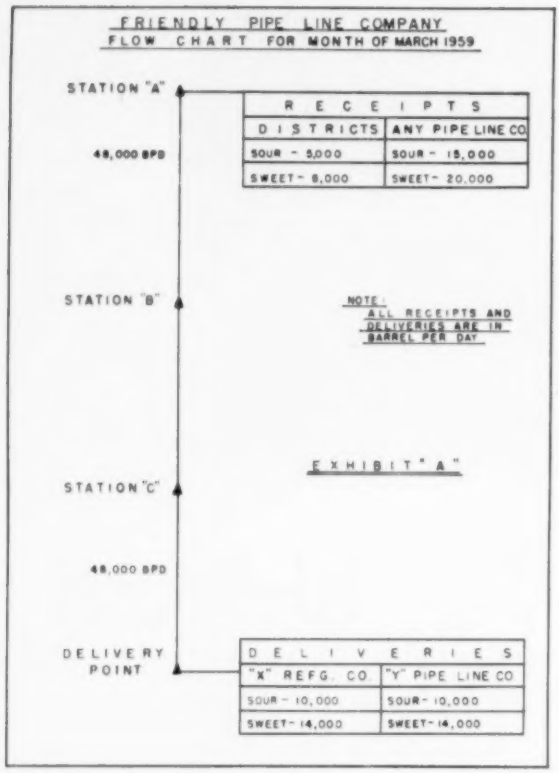


EXHIBIT "A"

advantage of the centralized organization is the close cooperation and coordination that is possible when all personnel concerned with a common problem are in the same general office.

Dispatching of pipelines can be handled for a location hundreds of miles away as easily as a pipeline 10 miles away, if adequate communications are available from the dispatching office to all pump stations, terminals, and refineries. The main disadvantage of the centralized organization is the cost of the communication facilities required in this type operation.

A primary advantage of a decentralized type organization is the close contact between field supervisors and field dispatchers, which is an aid in maintaining close working conditions. Of course, with the decentralized type of organization, it is not necessary to have communications between all stations, terminals, refineries, and the home office, but only to the area office. In this type of organization each area is a self-contained unit for dispatching purposes, and it is not necessary to report to the home office, except on total daily operations.

The centralized organization has the additional advantage of making available in the home office current information on all pipelines.

FUNCTIONS OF OIL TRAFFIC OR OIL MOVEMENT GROUP

Deal with shippers. The oil traffic group has the responsibility of obtaining schedules of receipts and deliveries from each shipper for each month. This information is usually received from the various shippers after the various state regulatory bodies have set the allowables, and will give the origin and amount of each grade of crude oil as well as the destination by grade and amount.

One shipper may transfer to another shipper in your lines, or he may ask you to deliver a certain amount of a specific grade to a connecting carrier for his account. Generally speaking, this information is received by telephone before the first of the month and is confirmed later by letter.

The receipt of a complete schedule from a shipper does not necessarily mean that schedule will remain in effect for the full schedule period, because many changes are made in schedules during the month. The changes are made when they can be coordinated by the dispatching group, however, at times it is necessary to refuse a change under certain operating conditions.

Tariffs. A check must be made to determine whether a tariff is in effect for all movements. In the case of interstate movements, it is necessary to have a tariff that has been approved by the Interstate Commerce Commission in Washington, D. C. ICC tariffs may be either of two types:

1. Joint pipeline tariff,
2. Local pipeline tariff.

All tariffs include the "Rules and Regulations" under which a pipeline movement will be made for a shipper. Items under this caption include:

1. Merchantable oil,
2. Storage,
3. Minimum tender,
4. Gaging, metering, testing and deductions,
5. Destination facilities required,
6. Duty of company,
7. Payment of transportation charges,
8. Apportionment when tenders are in excess of facilities.

EXHIBIT "B"

FRIENDLY PIPE LINE COMPANY PUMP SCHEDULE

Line Displacement "A" to "Del. Pt." — 200,000 bbls.

DATE	2,000 B.P.H. STATION "A" PUMP	"X" REF. CO. RECEIVE	"Y" REF. CO. RECEIVE
3-1-59	Start 7:00 AM So-6 80,000	Sw-3 8,000 Finish 11:00 AM So-4 40,000	
3-2-59	So-6 Finish 11:00 PM Sw-7 112,000	So-4 Finish 7:00 AM	Open 7:00 AM So-4 40,000
3-3-59	Sw-7		So-4 Finish 3:00 AM Sw-5 56,000
3-4-59	Sw-7	Open 7:00 AM Sw-5 56,000	Sw-5 Finish 7:00 AM
3-5-59	Sw-7 Finish 7:00 AM So-8 80,000	Sw-5 Finish 11:00 AM So-6 40,000	
3-6-59	So-8 Finish 11:00 PM Sw-9 112,000	So-6 Finish 7:00 AM	Open 7:00 AM So-6 40,000
3-7-59	Sw-9		So-6 Finish 3:00 AM Sw-7 56,000
3-8-59	Sw-9	Open 7:00 AM Sw-7 56,000	Sw-7 Finish 7:00 AM
3-9-59	Sw-9 Finish 7:00 AM So-10 80,000	Sw-7 Finish 11:00 AM So-8 40,000	

Form PL-35 (5-58) 100M

Pumping Order No. A-111 Houston, Texas, March 1, 1959

To Delivery Gauger At Delivery Point

After 7 A.M. today, Delivery Point will deliver batches as follows:

SW-3 for 8,000 bbls. to "X" Ref. Co.
SO-4 for 40,000 bbls. to "X" Ref. Co.
SO-4 for 40,000 bbls. to "Y" Ref. Co.
SW-5 for 56,000 bbls. to "Y" Ref. Co.

I. M. CHIEF

IMC-WM
10:30 A.M.

Form PL-35 (5-58) 100M

Pumping Order No. A-110 Houston, Texas, February 28, 1959

To Operator At Station "A"

Starting at 7:00 A.M., 3-1-59, Station "A" will pump following batches:

SO-6 for 80,000 bbls.
SW-7 for 112,000 bbls.
SO-8 for 80,000 bbls.
SW-9 for 112,000 bbls.

Station "A" will maintain maximum line pressure of 800 pounds at all times.

I. M. CHIEF

IMC-WM
10:00 A.M.

EXHIBIT "C"

There are other items, but these are the main ones. Tariffs also include origin points, destination, routing, and rates per barrel.

Intrastate movements require a tariff that has been approved by the various state regulatory bodies. In Texas, this means the Railroad Commission.

Shippers' tenders. Some pipeline companies operate on a strict shipper's tender basis, which means that all crude oil or products must be tendered by the shipper to the pipeline company for shipment on forms provided and accepted for movement by a representative of the pipeline company. The shipper's tender is then entered on the books as a shipping order, and billing for transportation is made upon completion of the tender.

Throughout the pipeline industry the use of shippers' tenders varies. Some companies do not even use them, whereas others make them only when a pipeline movement is made wherein two or more carriers are involved.

Make schedules and flow charts. After information is received from all shippers, it is then necessary to consolidate these figures into a form that is usable by the chief dispatcher. A flow chart is used for this purpose, and a flow chart is nothing more than schematic diagram of a system, showing all receiving and delivery points and the amount of each grade of crude oil to be received or delivered at that point. See example in Exhibit "A."

Generally, each shipper will vary the inventory in his system each month, either drawing down stock or building up inventories. This must be controlled by the oil traffic group because of available tankage. Close analysis is required on credit balances for each shipper in order to hold him at the proper level.

In addition to the information shown on the flow chart, it is necessary to know the accounts for which the oil is

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THE C·R·C PIPE SLING

Made especially for pipeline use, the C·R·C Pipe Sling permits safer handling of coated pipe. The sling is rubber covered and steel reinforced. Strong, but flexible, interlocking wire links enclosed in rubber give this belt high tensile strength . . . ultimate lifting capacity is 180,000 lbs. on 36 in. pipe size sling. Yet, the sling is just ⅝ in. thick for free usage in tight ditches. Call us for more details.

MAX. PIPE SIZE	PIPE SLING DIMENSIONS	SLING WEIGHT	IRON WEIGHT	ULTIMATE LIFTING CAPACITY
36"	12' 6"x30"x⅝"	237#	103#	180,000#
30"	10'x24"x⅝"	154#	84#	144,000#
24"	8'x20"x⅝"	106#	70#	120,000#
18"	6' 3"x16"x⅝"	71#	56#	96,000#
12"	4' 6"x12"x⅝"	39#	42#	72,000#

CRC

"SERVING PIPELINERS SINCE 1933"

CRUTCHER · ROLFS · CUMMINGS, INC.

Home Office: Houston, Texas, Box 2073, UNderwood 4-6391

Branch Office: Farmington, N. M., Box 1207, DAvis 5-5523
Export Office: International Oil Equipment Co., 30 Rockefeller Plaza, New York, N. Y., COlumbus 5-6250
In Canada: Canadian Equipment Sales & Service Co., Ltd., 7310 99th St., Edmonton, Alberta, Canada

to be received or delivered. We use an "account sheet" wherein is shown the following items:

1. Location of receipt or delivery,
2. Account or name of shipper,
3. Grade of crude,
4. Barrels per day,
5. Barrels per month.

These sheets are made individually for each system for both receipts and deliveries. This information is used by the chief dispatcher and his assistants in issuing instructions to the field for use in preparation of receiving or delivery tickets.

Proration and state regulations. Each state in which oil is produced has certain regulations that must be complied with by all producers and pipeline companies. Generally the oil traffic group must see that all regulations are complied with in the movements by pipeline. In Texas, the Railroad Commission has control of proration and other matters relating to the production and transportation of oil.

It is necessary that a tender, approved by the Railroad Commission, be obtained before the pipeline can receive, transport, or deliver crude oil. For refined products, an approved tender must be obtained before the products are moved from a refinery to a pipeline, but tenders are not required for deliveries to other pipelines or sales terminals.

SCHEDULING AND DISPATCHING OF CRUDE OIL

General. Scheduling and dispatching of crude oil can be accomplished by several methods. Systems in use vary from the "wake up in a new world every morning" method to the use of electrical computers. I shall not attempt to discuss all the various systems, but I plan to present to you the system we use and which we believe, after careful survey and study, is the most satisfactory and economical.

As you know, crude oil is produced and received into tank batteries, then pumped or moved by gravity into the gathering system and on into the trunk line stations. Oil at the trunk line station is usually received on a uniform rate from the gathering system, and oil from connecting carriers can be scheduled on a uniform basis. It is for this reason that we have gone to a "cycle system" of scheduling crude oil. "A cycle may be defined as a sequence of batches which are so sized as to meet the per diem requirements at a delivery point, or to meet the per diem production or receipts at an originating station."

This means that each seven days, or whatever number of days is decided upon, a station will pump that accumulation of each grade of crude. The number of days in a cycle is determined by a study of each system; that is, the tankage, volumes to be handled, pumping rates, and manpower situation.

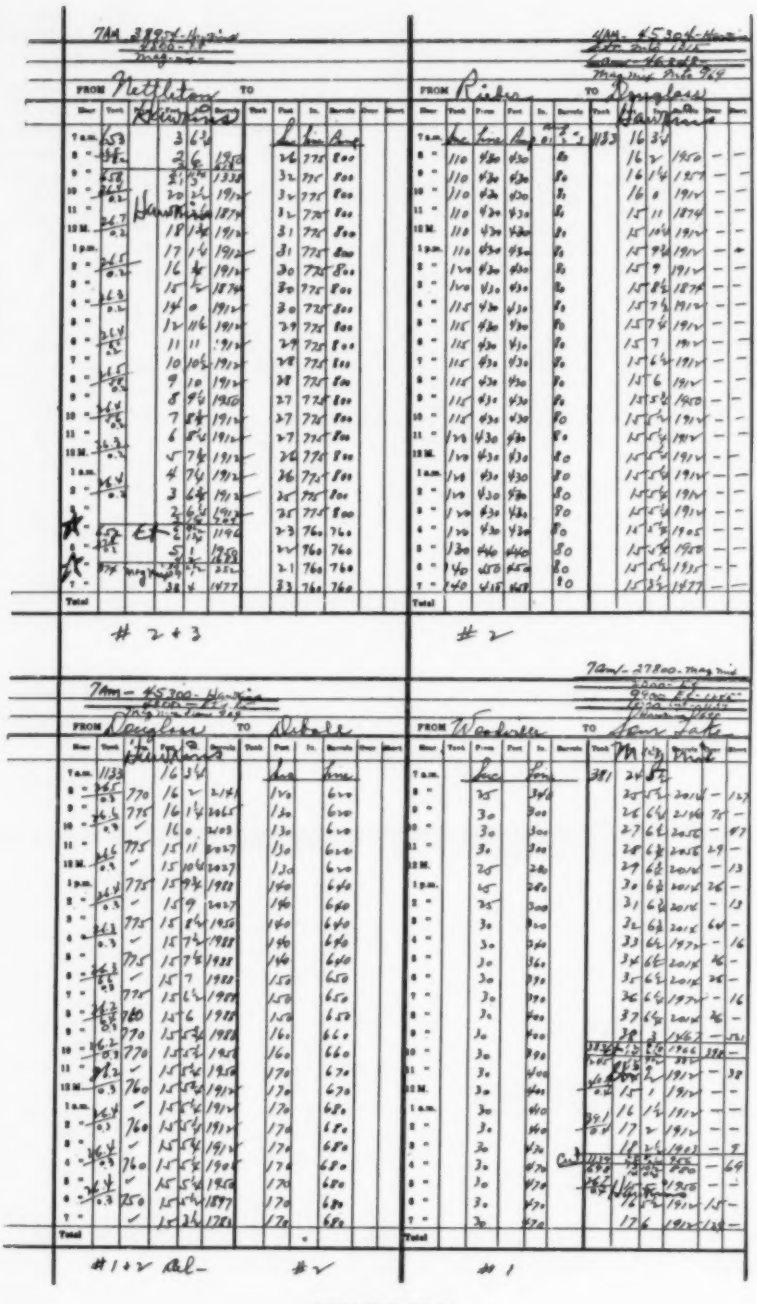

EXHIBIT "D"

Explanation of cycle system. As an example, let's look at the flow chart in Exhibit "A." On this system we would use a four-day cycle. You will note that Station "A" is to receive a total of 20,000 bbl per day of sour crude. Four times 20,000 equals 80,000 bbl of sour crude that Station "A" should pump each cycle. Station "A" also receives a total of 28,000 bbl per day of sweet crude. Four times 28,000 equals 112,000 bbl of sweet crude that Station "A" should pump each cycle.

Exhibit "B" shows a typical pumping schedule on the above cycle basis. Of course, this is a simple pipeline system and schedule, but this basic system can be adapted to any

system. On this schedule and pumping orders to follow, the grades are abbreviated as:

Sweet — SW

Sour — SO

Batches are also numbered consecutively for better control and handling in the schedule.

As you can see, we are then able to forecast a schedule for the full month for the entire system. It is necessary to check this schedule each day to see that receipts are coming in as predicted and the main line rate is satisfactory. Checks are also made on tankage at receiving points to insure that room is available in tankage for batches that will be in line.

By using this system, we are able to forecast the movement through our lines and work schedules for the month with our connecting carriers, both receiving and delivering, and to our refineries. We are better able to plan shutdowns for maintenance work and better utilize our field manpower. It also simplifies our job in the dispatching office in that we place full responsibility for scheduling on our chief dispatcher and his assistants and provide him with all necessary information to accomplish that responsibility.

Pumping orders. In order to convert the aforementioned pumping schedule into actuality, the chief dispatcher issues written pumping orders to each station, terminal, or other delivery point. These pumping orders are transmitted to the required location by teletype or telephone.

Exhibit "C" shows a typical pumping order as issued by the chief dispatcher. Pumping Order A-110 follows the schedule as shown in Exhibit "B"; Order A-111 will be explained in detail later.

In addition to example shown here, pumping orders tell stations the number and type of units to operate, maximum allowable line pressure, and other information essential to pipeline operation.

Daily pumping record. In order for the dispatching office to perform their function of directing the oil movement, it is necessary that each station, terminal, or delivery point transmit to the dispatcher each hour certain information to be recorded on a daily pumping record. Such a sheet is shown in Exhibit "D." You will notice that this record starts at 7:00 a.m. each day — the normal pipeline day — and continues until the following 7:00 a.m., giving us 24 hours activity on each sheet. Each station with tankage reports:

1. Tank number,
2. Suction, line, and pump pressures,
3. Tank gage in feet and inches,
4. Barrels pumped or received,
5. API gravity and BS&W (each 2 hours).

Relay stations report suction, line and pump pressures, as well as amperes on electric units or revolutions per minute on diesel stations. The dispatchers write above each station a summary of the pumping orders for that station in order that he can check the activities at the station while he is recording each hourly report. This hourly report is commonly referred to as an "OS."

The information recorded on the "OS" sheet is used by the dispatchers to see that each station complies with all pumping orders and to analyze the movements for possible trouble. The dispatcher is the only man on the pipeline with information on all lines, and it is his prime responsibility to use this information to watch and control the pipelines.

Part 2 will appear in an early issue.

F.H. Maloney
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But Scraper Cups operate in the dark, where looks don't count, and performance does. It is at the end of the run, in the receiving barrel, where performance shows up.
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It creates a bond between fully plasticized coal tar enamel and metal that strengthens as it serves... that, when properly applied, increases the reliability factor of the application process on steel pipe and tank surfaces to a comfortable 100%.

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Pipeline Projects

Trunkline's 895-Mile Project Authorized

Reversing an examiner's decision, the Federal Power Commission has authorized Trunkline Gas Company to expand its natural gas transmission system by 895 miles of pipeline, by 135,000,000 cu ft of natural gas per day, at an estimated cost of $81,458,000. The FPC concluded that the market, gas supply and facilities were adequate, the estimated cost reasonable, and the project financeable and economically feasible.

The facilities will enable Trunkline to provide 129,000,000 cu ft daily to Consumers Power Company of Jackson, Michigan, and 6,000,000 cu ft per day to Michigan Gas Utilities Company of Coldwater, Michigan. Trunkline originally proposed to supply the entire 135,000,000 cu ft to Consumers Power, but the FPC granted the request of Michigan Gas, which intervened in the proceeding to obtain a supply of gas from the new project.

The FPC conditioned the authorization to require Trunkline to file revised rate schedules reducing the proposed price of the gas to the two new customers from a 100 percent load factor average of 45¾ cents per Mcf to about 40 cents.

Trunkline's project includes additional compression and loop lines paralleling various sections of its existing system in Texas and between Longville, Louisiana, and Tuscola, Illinois; and a 204-mile extension of the company's system from Tuscola, to the Michigan-Indiana border, near White Pigeon, Michigan, where it will connect with facilities to be built by Consumers and Michigan Gas Utilities Company.

The facilities will enable Trunkline to transport gas produced in Brazoria and Galveston Counties, Texas, and from offshore Cameron and Vermilion Parishes, Louisiana, as well as onshore Vermilion Parish.

The Commission's order also grants 13 applications by eight independent producers for sales of natural gas to Trunkline in Texas and Louisiana, and an application by Michigan Gas Storage Company of Jackson, Michigan, relating to Trunkline's project.

July 7 Hearing Set On El Paso Proposal

El Paso Natural Gas Company's application to construct and operate field and mainline facilities to supply an additional 100,000,000 cu ft of gas daily to Pacific Gas & Electric Company will be heard July 7 by the Federal Power Commission.

El Paso expects to obtain additional gas from Terrell County, Texas, Lea County and the Bisti field in San Juan County, New Mexico, and the Pictured Cliffs formation in the Tapacito area of the San Juan Basin. Delivery to PG&E would be on the Arizona-California boundary near Topock, Ariz.

The company estimates the proposed facilities will cost $46,543,000 then an additional $127,000 will be needed for financing costs, and that the company will need $600,000 more in working capital, making a total estimated cash requirement for the project of $47,270,000.

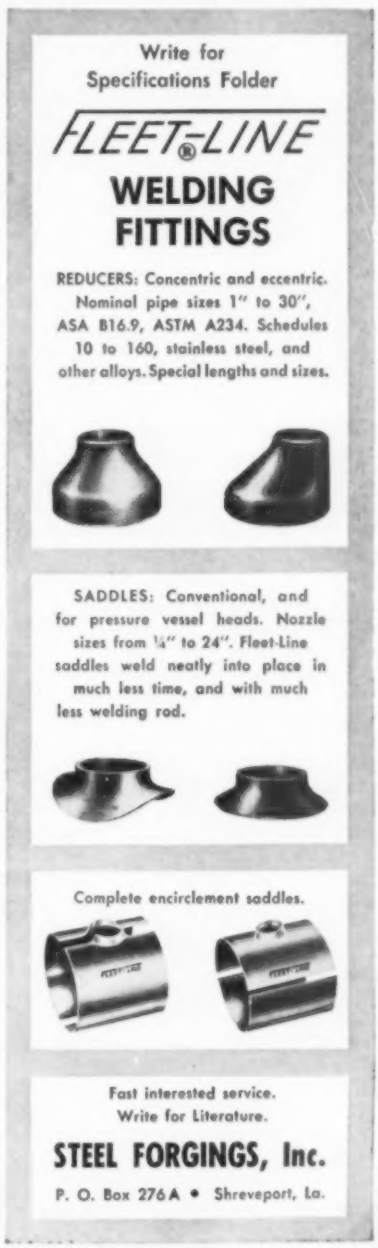
CONSTRUCTION FEATURE

The proposal includes construction of about 118 miles of 30-in. loop pipeline and 24,500-hp in new and existing compressor stations. The company also would build field facilities consisting of approximately 344 miles of 2 to 20-in. pipelines, 12,900 additional hp in existing stations, a 25,000,000 cu ft per day increase in the capacity of its Chaco gasoline plant, and treating and dehydration plants.

Laterals Under Construction

A completion date of September 30 is the target for an Alberta Gas Trunk Line Company construction project now underway by Engelking & James, Ltd.

The $2,500,000 project consists of approximately 55 miles of 6 and 8-in. laterals in the Wayne area, in the vicinity of Chancellor, in the Makepeace area, and in the Consort and Hilda areas.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FLEET-LINE
WELDING FITTINGS
REDUCERS: Concentric and eccentric. Nominal pipe sizes 1" to 30", ASA B16.9, ASTM A234. Schedules 10 to 160, stainless steel, and other alloys. Special lengths and sizes.
SADDLES: Conventional, and for pressure vessel heads. Nozzle sizes from ¼" to 24". Fleet-Line saddles weld neatly into place in much less time, and with much less welding rod.
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Projects

New Line Started Traversing Illinois

Construction has begun on a $17,000,000, 60-mile natural gas pipeline to extend from near Joliet, Illinois, to the Calumet distribution station of The Peoples Gas Light and Coke Company. Completion is expected by next fall.

Fifty miles of 36-in. and two miles of 30-in. will be built by Chicago District Pipeline Company, a Peoples Gas subsidiary. Estimated to cost $12,900,000, it will extend eastward and northward from a point south of Joliet to the city limits of Chicago. Peoples Gas will expend about $4,000,000 to build the remaining portion of 36-in. line.

Chicago District's new facility, to be known as the Third Calumet Line, will traverse the same general area as dual lines it presently operates to serve the south side station. Its designed capacity of 557,000,00 cu ft per day is large enough to handle additional supplies from future expansion projects. It will cross under the Des Plaines and Grand Calumet rivers by trenching, and under the Calumet river in a tunnel.

Construction is beginning simultaneously by Peoples Gas at the Chicago city limits and by Chicago District at the point of inter-connection with Texas Illinois' facilities.

Examiner Approves "Boiler Fuel" Plans

Citing the air pollution problem in Los Angeles, California, a Federal Power Commission examiner has approved El Paso Natural Gas Company's plan to supply a maximum of 100,000,000 cu ft of gas per day to Southern California Edison Company for steam electric power plant use and to supply "peaking service" to Southern California Gas Company and Southern Counties Gas Company.

Presiding Examiner Samuel Binder, in his decision, said that the use of natural gas as boiler fuel in that area should be considered as being in a different category than gas being used for such a purpose in some other community where the smog problem does not exist.

The $24,000,000 pipeline facilities — part of an overall $55,502,000 project that started in 1958 when the FPC authorized El Paso to build only the facilities necessary to connect new sources of gas supply and then remanded the case to the examiner to determine El Paso's ability to supply gas for the proposed service — includes 126 miles of loop at various points along El Paso's Permian-San Juan crossover line route and additional mainline compressor horsepower at new and existing stations.

El Paso will deliver gas to Southern California Gas Company and Southern Counties Gas Company near Topock, Arizona, or Blythe, California, for the Southern California Edison account. Although the contract had provided for El Paso's deliveries to increase 25,000,000 cu ft per day each year after 1959, from 100,000,000 to a maximum of 300,000,000 cu ft daily, the examiner limited the sales to 100,000,000 cu ft daily.

The decision is subject to FPC review.

Examiner Okays UGPL Project

United Gas Pipe Line Company is authorized, in a Federal Power Commission examiner's decision subject to FPC review, to construct pipeline facilities to enable it to receive gas from the North Henderson field area of Rusk County, Texas.

United's $696,369 proposal includes construction of approximately 14 miles of 12-in. pipeline and four purchase meter stations.

The decision at the same time authorizes Phillips Petroleum Company and Union Producing Company to sell gas to United in this area. The examiner rejected the FPC staff recommendation to condition the certificates to limit the initial price of the gas. The staff suggested varying prices between 14 and 16 cents but indicated that 15.4 cents would be most appropriate. United's contracts with the two producers provide for an initial price of 17 cents.

Present deliverability from the area is estimated at 12,000,000 cu ft daily, increasing to 24,000,000 cu ft daily when the area is fully developed. United then expects to purchase between 6 and 8½ billion cu ft of gas per year.

Short United Line Gets Temporary Okay

An 18-mile, 26-in. natural gas transmission line designed to give United Fuel Gas Company sufficient capacity to meet the demands of its customers and for its storage injection program has been granted a temporary certificate by the Federal Power Commission.

The line, estimated to cost $2,512,400, will be located in Kanawha County, West Virginia.

United Fuel, a Columbia Gas System subsidiary, had estimated that without the construction it would have a deficiency of 47,700,000 cu ft of gas on an average May day in 1959, increasing to more than 150,000,000 cu ft in 1960. Increased injections into storage in the summer of 1959 will assure United's ability to meet its 1959-60 winter requirements.

Products Line To Get 279-Mile Extension

Kaneb Pipe Line Company has embarked upon a multi-million dollar expansion program that will increase the company's present size from 246 miles to 525 miles and facilitate transportation of refined petroleum products from the producing-refining areas of southern Kansas into the northern Nebraska-South Dakota areas. Present plans call for completion of the 279-mile extension in September or October of this year, according to President Herbert E. Fisher.

The expansion program that will more than double Kaneb's present size includes a 168-mile extension of the products pipeline system from the Kaneb Fairmont Terminal near Geneva, Nebraska, to a point near Yankton, South Dakota, and a 111-mile line from the Cooperative Refinery Associations' refinery at Phillipsburg, Kansas, to the Fairmont Terminal.

Two new pumping stations at Phillipsburg and Fairmont and modern multi-products terminals at Norfolk, Nebraska, and Yankton will be included in the expansion program.

Pipe Line Technologists, Inc., of Houston, Texas, who designed and supervised the construction of the original line, has designed and will supervise construction and operation of the extension.

The present system consists of 200 miles of 10-in. line, 46 miles of 8-in., and six pumping stations. It originates in the Wichita and El Dorado, Kansas, refining areas and extends to the Kaneb-owned multi-products Fairmont Terminal near Geneva, Nebraska.

Loop Lines Get Temporary Okay

Atlantic Seaboard Corporation's proposal to construct and operate approximately 26 miles of natural gas transmission line on its system in West Virginia, Virginia, and Maryland has received temporary authorization from the Federal Power Commission, but the temporary certificate specifically excluded the company's proposed one mile of 10-in. pipeline to connect with Transcontinental Gas Pipe Line Corporation's system near Dranesville, Virginia. Transco has pending before the FPC an application involving the delivery of an additional 25,000,000 cu ft of gas per day to Atlantic Seaboard at Dranesville.

The facilities involved in the temporary authorization are estimated to cost $5,869,000 and include about 19 miles of 26-in. loop line, about 6 miles of 20-in. loop line, and a new 8000-hp compressor station.

Atlantic Seaboard Corporation is a Columbia Gas System subsidiary.

New Capacity High Tennessee Gas Goal

Construction is underway on Tennessee Gas Pipeline Company's $69,000,000 project which includes the largest compressor construction program in company history, plus substantial additions to its pipeline system. When completed and placed in service this fall, the facilities will increase delivery capacity of the system to new highs of more than 2.5 billion cu ft on average days and 2.9 billion on peak days, using underground storage.

The additional capacity will be used by the company to provide larger volumes of gas to meet the growing requirements of its existing customers, and to furnish a gas supply for Midwestern Gas Transmission Company, wholly-owned subsidiary of Tennessee Gas Transmission. Midwestern will begin service to Chicago area utilities this fall through a new pipeline to be built this year (see related story elsewhere in "Pipeline Projects," this issue).

The compressor construction program calls for addition of 113,100-hp to the system through construction of four new stations and enlargements of 13 existing stations. It will expand present total horsepower of the system, now aggregating 641,300 in 39 principal stations, by about 18 percent.

Pipeline contracts totaling 201 miles of line in Tennessee, Kentucky, and West Virginia have been let. Including 173 miles of 30-in. and 28 miles of 26-in. pipe, the line will be laid parallel to the existing system by three contractors as follows: Williams Brothers, Western Pipe Line, Inc., and the H. C. Price Company.

Northern Nat'l Begins Project

Construction has already begun at several locations along Northern Natural Gas Company's line as a result of Federal Power Commission approval of the company's proposal to increase its transmission system capacity by 100,000,000 cu ft daily to serve Northern Illinois Gas Company and 23 existing customers. (See *Pipeline Engineer*, June 1959).

Single 2000-hp additions are being installed at Ogden, Iowa; Palmyra, Nebraska; and Mullinville, Bushton, and Clifton, Kansas. Two 2000-hp units are being constructed at Beatrice. Also, work has started on approximately 9 miles of 30-in. loop line north of Mullinville.

The completed program calls for about 103 miles of 30-in. loop line and the installation of 14,000 compressor hp. Approximately 18 miles of 20-in. line will be built from Northern's present line near Dubuque and cross the Mississippi River to connect with Northern Illinois' line.

Northern Illinois previously received permission from the Illinois Commerce Commission to begin its $12,500,000 expansion program that calls for a 140-mile 22-in. pipeline that would bring Northern's gas into Northern Illinois' present system at Des Plaines, Illinois. (See related story, "Pipeline Projects," this issue).

Midwestern Plans To Deliver Gas by Fall

Midwestern Gas Transmission Company will begin construction immediately on its recently authorized system with a view to delivering gas to the Chicago area this fall. At the same time Midwestern's parent company, Tennessee Gas Pipeline Company, which will supply the gas, is getting underway with additions to its system to take care of this additional load. (See related story in "Pipeline Projects," this issue.)

The Midwestern project, which will cost an estimated $50,815,000, will consist of 350 miles of 30-in. pipeline from Portland, Tennessee, to Joliet, Illinois, and two compressor stations with total horsepower of 14,300. The line will connect with Tennessee's system at Portland and with the Chicago District Pipeline Company at Joliet.

Gas will be supplied to Peoples Gas Light and Coke Company in amount of 100,000,000 cu ft a day; Northern Indiana Public Service Company, 200,000,000 cu ft, and Northern Illinois Gas Company, 60,000,000 cu ft.

Fall Completion Set For Jet Fuel Pipeline

A target date of November 1 is set for completion of Florida's first jet fuel pipeline — a $2,000,000, 8-in., 54-mile pipeline that will carry aviation's lifeblood below the surface from Port Everglades to Homestead Air Force Base at a rate of 220,000,000 gal annually.

Operation of the line by the Onego Corporation's Florida Pipeline & Storage Company will eliminate the hazardous need to transport the highly volatile fuel in tank cars and trucks, and savings to the Air Force's Strategic Air Command is estimated to be more than $200,000 a year.

The proximity of the line to Miami International Airport — it is only half a mile at its closest point — will make the line available to that terminal via a new trunk spur. The spur can be connected to the storage tanks on the field used to pump fuel directly into the airport's newly constructed hydrant fuel system.

Ewin Engineering Corporation has asked for bids on construction of the Florida line.

NI-Gas Starts 140-Mile Line

Construction is underway on Northern Illinois Gas Company's 22-in., 140-mile line that will transport 50,000,000 cu ft of natural gas per day from a connection with Northern Natural Gas Company's system near East Dubuque to Northern Illinois Gas' facilities near Des Plaines, Illinois. The line is scheduled to be in operation by September 30.

The project will cost about $12,500,000, according to Loren W. Tuttle, vice president of Northern Illinois Gas.

Contracting and Material Company has received contracts for installation of the line, and Williams Brothers Company is engineering and supervising construction.

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Projects

Spreads Working On Alberta Line

The Alberta Gas Trunk Line Company Ltd. is well advanced on its major main line extension for 1959, with spreads working on both sectors. Mannix Ltd., Calgary, kicked off on May 15 with pipelaying on 122 miles of 30-in. line from Princess Junction to Torrington, in central Alberta. V. J. (Slim) Worcester is spread superintendent. Double-jointing of all pipe was decided on, and subbed to H. C. Price Co. The Mannix field office is at Brooks.

Two laterals are being laid by Marine Pipeline & Dredging Ltd., Vancouver. The first, 33 miles of 16-in. line, will connect the Carstairs field with the main line at Torrington. This job was kicked off on May 1, at Carstairs. The same spread will move onto the other lateral, 46 miles of 16-in. from Nevis to Torrington, and will complete the job by July 15, according to current schedule. W. R. Gilbert is spread superintendent.

Plan Midale Field Link

Trans-Prairie Pipelines, Ltd., plans to extend its pipeline system in southeastern Saskatchewan to service the South Halbrite pool of the Midale field. A permit has been sought from the Saskatchewan Dept. of Mineral Resources.

Construction plans call for a gathering system and trunk line to service batteries in three sections of land, two of which adjoin. The line would end at an existing truck-loading terminal on the Trans-Prairie trunk line four miles away.

Trans-Prairie owns and operates a trunk line and gathering system servicing the Weyburn and West Kingsford fields in the southeast which connects with the western terminal of Westspur Pipe Line Company near Midale.

The company also owns the gathering system which services the oil fields in the southwest corner of the province. This reaches Regina via the South Saskatchewan Pipe Lines.

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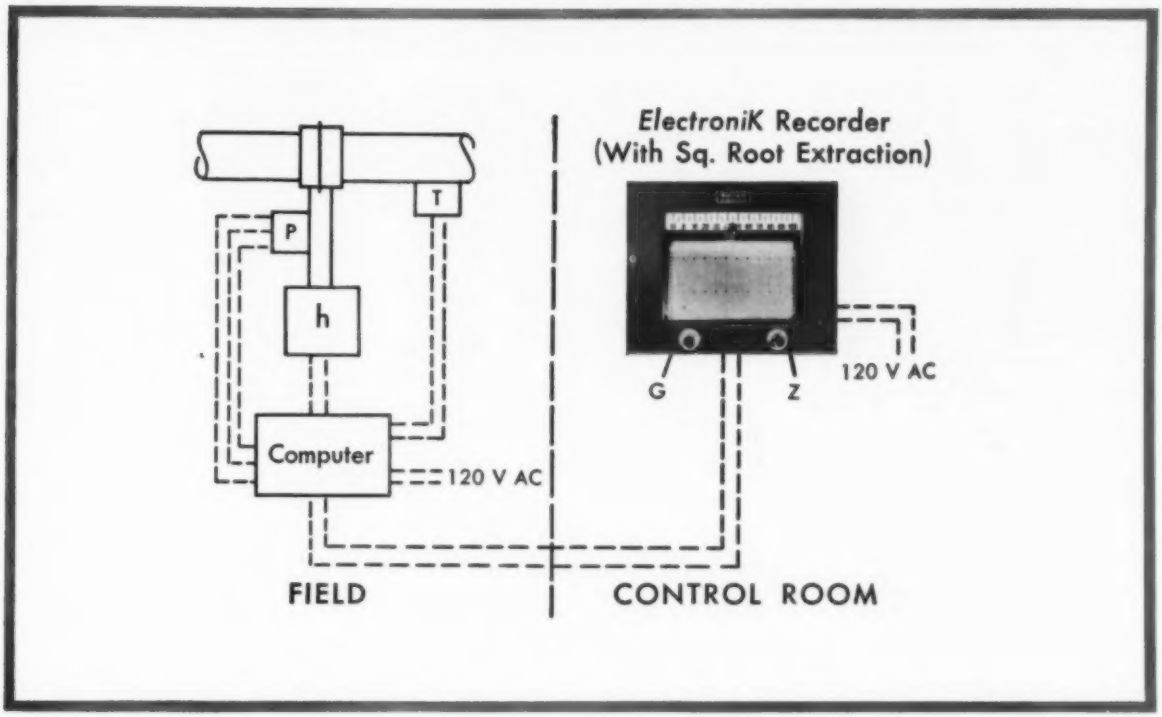

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PIPELINE PERSONALS

W. K. Warren, chairman of the board and chief executive officer of Warren Petroleum Corporation and director and member of the executive committee of Gulf Oil Corporation has been elected to the board of directors and chairman of the board of Transwestern Pipeline Company. **John R. McMillan,** president of Monterrey Oil Company, was elected vice chairman of the Transwestern board; and **J. R. Butler** of Houston was named chairman of the executive committee and secretary and treasurer of the company. Warren, President **Mills Cox,** and McMillan are other members of the executive committee. Other members of the Transwestern board are: **R. M. Chan,** petroleum consultant of Dallas; and **William B. Padon,** vice president of Warren Petroleum Corporation. Other officers elected were: **W. H. Simmons,** assistant secretary and treasurer; and **Mrs. Lorrain Stratton,** assistant secretary.

W. K. Warren

R. W. Lee, assistant superintendent of Continental Pipe Line Company's Oklahoma-Kansas-Illinois district, has been promoted to district superintendent and will be succeeded in his former position by **W. R. Keathly.**

Robert E. Allen has joined Panhandle Eastern Pipe Line Company as corrosion engineer at Tuscola, Illinois. He was formerly associated with Celanese Corporation of America in Pampa, Texas.

J. S. Noel has been named superintendent of Transcontinental Gas Pipe Line Corporation's new Trucksville, Pennsylvania, pipeline district, and **Wendell Q. Scott** has been appointed superintendent of the company's new Thibodaux, Louisiana, pipeline district.

W. K. Sanders, president of Trunkline Gas Company, a subsidiary of Panhandle Eastern Pipe Line Company, has been elected a director of the parent company, succeeding **M. K. Hager.** Hager recently retired as vice president in charge of operations and a director.

Harry E. Otell, Jr., formerly with Lone Star Gas Company and Trunkline Gas Company, has been appointed chief petroleum engineer by Coastal Transmission Corporation. Otell will assist the vice president, gas supply, in the evaluation of gas reserves which may be dedicated to the Coastal-Houston project and will estimate and redetermine, where necessary, the gas reserves and deliverability in the various fields that have already been dedicated to the Coastal-Houston project. In other appointments, Coastal named **Harvey G. Dudman** as superintendent of communications and cathodic protection; **Robert C. Imler** as right-of-way manager; and **Bobby E. Crow** as ad valorem tax man.

H. E. Otell, Jr.

H. G. Dudman

R. C. Imler

D. G. Shingledecker has been appointed main line superintendent of New York State Natural Gas Corporation. He will supervise the construction and major maintenance of main transmission lines from his headquarters in the company's main office in Pittsburgh, Pennsylvania.

Jack W. Seaman has been appointed general manager of the recently-opened Midland, Texas, offices of Permian Basin Pipeline Company, and **Richard E. Mayne** has been named manager of staff services in Permian's staff realignment. Other Permian supervisory personnel headquartered at Midland include: **Otto Barbee,** manager of plants; and **Roy Schollenbarger,** manager of pipelines. Seaman joined Northern Natural Gas Company, Permian's parent firm, in 1938 and held the post of assistant superintendent of compressor stations before his promotion and transfer to Midland. Seaman said the Permian staff will occupy quarters in the Midland Savings and Loan Building until permanent offices in the Pan American Building are completed about October 1.

J. W. Seaman

Robert E. Gregory has been named director of employee relations in Columbia Gulf Transmission Company's new employee relations department. As manager of training and safety, Gregory has been a member of the transmission department. Assigned to his staff are: **Chester O. Burns** as safety director and **Richard D. Harrison** as information supervisor.

L. B. Mulloy, station foreman with Service Pipe Line Company, has been transferred to El Reno, Oklahoma, and Sterling City, Texas.

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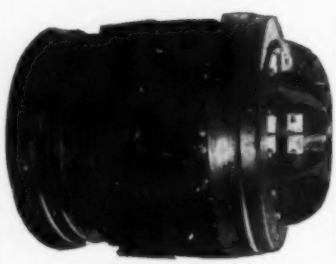

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● **Associated Pipe Line Contractors, 3115 Buffalo Drive, Houston, Texas.** Has been awarded contracts by *The Rotterdam-Rhine Pipeline* to build 59 miles of 30-in. and 96 miles of 24-in. crude line from Rotterdam to Godorf and Wesseling, Germany, and a 25-mile smaller line to a Gelsenkuchen refinery.

● **Bechtel Corporation, 220 Bush Street, San Francisco 4, California.** Has been awarded a contract by *Midwestern Gas Transmission Company* to double joint 210 miles of 30-in. in Illinois and Indiana. A. U. Rigby is superintendent.

● **Brown & Root, Inc., 4100 Clinton Drive, Houston, Texas.** Has contract with *Texas Eastern Transmission Corporation* to furnish field supervision for construction of 626 miles of 30-in. loops along the company's line between Beaumont, Texas, and Uniontown, Pennsylvania.

● **O. R. Burden Construction Corporation, P. O. Box 5216, Tulsa, Oklahoma.** Has been awarded a contract by *Northern Oklahoma Gas Company* to install 70 miles of 10 and 12-in. line between Cherokee and Ponca City, Oklahoma; and has been awarded a contract to construct 62 miles of 8-in. petroleum products pipeline connecting the *Texas Eastern Transmission Corporation* refinery at Tyler to the Little Big Inch pipeline system at Carthage. Has contract also to construct 93 miles of 8 to 20-in. gathering system from Falfurrias to McAllen, Texas, for *South Texas Natural Gas Gathering Company*. R. M. Jones is spreadman, with field office at Falfurrias.

● **Coates Field Service, Inc., P. O. Box 1581, Oklahoma City, Oklahoma.** Has contract for right-of-way acquisition for the *Peoples Natural Gas Company* on their 30-mile gas line located between Gibson and Imperial, Pennsylvania; and for *South Georgia Natural Gas Company* on their 113-mile line in Georgia.

● **Collins Construction Company, P. O. Box 86, Port Lavaca, Texas.** Has been awarded contracts for the following work: 25 miles of 30-in. line from Ganaweh, Iran, to Khargu Island in the Persian Gulf, with H. C. Frankmann supervising; 25 miles of dual 32-in. lines from Fao, Iraq, to an artificial loading island, with Frankmann supervising; 52 miles of varying diameter from Mainland, Canada, to Vancouver Island; 5400-ft of 27½-in. from Tema, Ghana, into the ocean, with Lex King supervising; and a dual 6-in. pipeline link between Europe and Asia across Bosporous.

● **Contracting & Material Company, 1235 Dodge Avenue, Evanston, Illinois.** Has been awarded a contract by *Northern Illinois Gas Company* for the construction of a 22-in. natural gas pipeline between East Dubuque and Des Plaines, Illinois, with James H. McGill as project manager.

● **Dutton-Williams Brothers, Ltd., North Canadian Oil Building, Calgary, Alberta, Canada.** Has been awarded a contract by *Saskatchewan Power Corporation* to construct 80 miles of 10-in. from Success to Rosetown.

● **Engelking & James, Ltd., 408A 16th Avenue, N.E., Calgary, Alberta, Canada.** Has been awarded a contract to construct approximately 20 miles of 6-in. laterals in the Wayne, Chancellor, and Makepeace areas for *Alberta Gas Trunk Line Company, Ltd.*, and approximately 34 miles of 8-in. laterals in the Consort and Hilda areas.

● **Engineering-Construction Company, First National Bldg., Tulsa, Oklahoma.** Has received contract to lay 25 miles of various diameter lines for *North Carolina Natural Gas Corporation* from the company's main line to various tobacco farms. J. N. Underwood has been named superintendent, Paul Williams is foreman, and V. L. Bethel is office manager.

● **Fulghum Contracting Corporation, P. O. Box 1181, Harrisburg, Pennsylvania.** Has been awarded a contract to lay 100 miles of 12-in. pipeline from Watertown to Massena, New York, for *Niagara Mohawk Power Corporation*.

● **Fulton Banister, Ltd., 625 Northern Hardware Bldg., Edmonton, Alberta.** Has contract to lay 47 miles of 6-in. from Edson, Alberta, to Windfall field, 35 miles west of Whitecourt, for *Hudson's Bay Oil and Gas Company Ltd.* Field offices are at Whitecourt and Edson, with George Caron as superintendent.

● **R. H. Fulton & Company, P. O. Box 1526, Lubbock, Texas.** Has been awarded a contract by *Michigan Wisconsin Pipe Line Company* to build 211.7 mile of 24-in. pipeline in Kansas, Nebraska, and Missouri. Also has contract from *Northern Natural Gas Company* to lay 11 1/10 miles of 30-in. pipeline north of Sunray, Texas, and 8 1/10 miles of 30-in. north of Beaver, Oklahoma, with A. A. Carrigan as job superintendent in the field office at Beaver.

● **H. L. Gentry Construction Company, 921 East Michigan, Jackson, Michigan.** Has been awarded a contract by *Peoples Natural Gas Company* to lay 22 miles of 24-in. from Waynesburg, Pennsylvania, where the field office is located, to the West Virginia state line. Frank Morris has been named spreadman.

● **Houston Contracting Company, 2807 Buffalo Speedway, Houston 6, Texas.** Has contract to lay approximately 117 miles of 30-in. natural gas pipeline for *Texas Gas Transmission Corporation* in central and north Louisiana, with R. L. Silar as superintendent. Also awarded contract to construct 41 miles of 30-in. natural gas pipeline for *United Gas Pipe Line Company* in the vicinity of Gulfport, Mississippi, and Mobile, Alabama. M. L. Thompson has been named superintendent.

● **Latex Construction Company, Box 12128, Atlanta 5, Georgia.** Has been awarded the following contracts: *Arkansas Fuel Oil Corporation*, the enlargement of a marine terminal at Port Everglades, Florida, R. D. Copeland in charge; *Everglades Pipe Line Company*, 35 miles of 10-in. from Ft. Lauderdale to Miami, Florida, with O. P. Hiner in charge, and construction of a pumping station in Port Everglades, with D. C. Rinehart in charge; and *Plantation Pipe Line Company*, reconditioning 90 miles of 4, 10 and 12-in. in Georgia, Mississippi, and South Carolina, G. H. Matlock in charge.

● **Macco Corporation, 14409 South Paramount Boulevard, Paramount, California.** Has prime contracts with various companies to construct pipelines in various sizes through 30-in. in California.

● **Majestic Contractors, Ltd., 408 Royal Trust Building, Edmonton, Alberta, Canada.** Has been awarded an undetermined amount of 4 through 10-in. crude oil gathering system to be constructed in the Estevan, Saskatchewan, area for *Producers Pipeline Company*.

● **Mannix Company Ltd., 737 8th Avenue, S.W., Calgary, Alberta, Canada.** Has been awarded a contract to construct 122 miles of 30-in. for *The Alberta Gas Trunk Line Company Ltd.* from Princess to Torrington, Alberta, with field office located in Brooks and V. J. Worcester as superintendent. Also has received a contract from *Pembina Pipe Line Ltd.* to lay 40 miles of 3 to 6-in. from the Pembina field. Field office for the latter is located in Drayton Valley, Alberta, and superintendent is S. Steffen.

● **Marine Pipeline & Dredging Ltd., 640 West Hastings Street, Vancouver 2, B. C., Canada.** Has been awarded a contract by *Saskatchewan Power Corporation* to construct 113 miles of 8-in. from Regina to Yorkton and 72 miles of 4 and 6-in. from St. Louis to Tisdale.

● **J. Ray McDermott & Company, Inc., P. O. Box 38, Harvey, Louisiana.** Has been awarded a contract by *Venezuelan Sun* for an 18-in. crude pipeline from Block 1 in Lake Maracaibo to a terminal at Punta Palmas.

● **Panama, Inc., 2201 Commerce Building, Houston 2, Texas.** Has been awarded a contract by *Humble Oil & Refining Company* to construct 238 miles of 30-in. natural gas pipeline from the King Ranch in Texas to the Clear Lake gas plant in Houston, Texas.

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Contractors

● **Panama-Williams Corporation, 1418 Melrose Bldg., Houston, Texas.** Has been awarded a contract to lay approximately 125 miles of 24-in. pipeline in the vicinities of Centerville and Mt. Pleasant, Iowa, and Kewanee, Illinois, for *Michigan Wisconsin Pipeline Company*.

● **Pentzien, Inc., 1504 Dodge Street, Omaha, Nebraska.** Has been awarded a contract by *Michigan Wisconsin Pipe Line Company* to install a single 24-in. submarine crossing of the Missouri River. Spreadman is James R. Zeman, and field office is located at Rulo, Nebraska.

● **H. C. Price Company, Price Tower, Bartlesville, Oklahoma.** The pipe coating division has the following jobs in progress. At Harvey, Louisiana: For *United Gas Pipe Line Company*, 75 miles of 6 to 30-in., somastic coating, and 71 miles of 6 to 30-in., hevicote concrete coating; *Transcontinental Gas Pipe Line Corporation*, 25 miles of 20-in., somastic and hevicote coatings, 5 miles of 8-in., somastic coating, and internal coating to 1 mile of 20-in.; *Hunt Oil Company*, 2 miles of 6-in., somastic coating. At Vanderbilt, Texas, railhead plant: *Humble Oil & Refining Company*, 6 miles of 30-in., hevicote coating; and *Coastal Transmission Corporation*, 7 miles of 20-in., hevicote coating. At West Point, Kentucky, railhead plant: *Tennessee Gas Transmission Company*, 140 miles of 30-in., internal epoxy paint. At Philadelphia, Pennsylvania: *Atlantic Refining Company*, 6 miles of 30-in., somastic coating, and 3900 ft of 30-in., hevicote coating; *Brooklyn Union* Gas Company, hevicote to 2 miles of 24-in.; *Commonwealth Edison Company*, somastic and interior coating to 8 miles of 5-in.; *Consolidated Edison Company*, enamel coating to 1 mile of 30-in.; *Florida Power Corporation*, somastic and interior coatings to 4 miles of 6-in.; *Samuel Gallucci & Sons, Inc.*, hevicote coating to 2 miles of 24-in.; *General Cable Corporation*, somastic coating to 3397 ft of 6-in. and interior coating to 1 mile of 6-in.; *The Okonite Company*, somastic and interior coatings to 4 miles of 5-in.; *Phelps Dodge Corporation*, somastic coating to 14 miles of 6 to 8-in. and interior coating to 20 miles of 6 to 8-in.; *Philadelphia Gas Works*, 32 miles of 3 to 20-in., somastic coating; *Philadelphia Electric Company*, 28 miles of 6 to 20-in., somastic coating; *Public Service Electric & Gas Company*, somastic coating to 2 miles of 4 to 8-in. and interior coating to 3 miles of 4 to 8-in.; and *Transcontinental Gas Pipe Line Corporation*, somastic coating of 48 miles of 36-in. A contract for pipeline construction has been received from *Tennessee Gas Pipeline Company* for approximately 30 miles of 30-in. in Kentucky and approximately 29 miles of 26-in. in Kentucky and West Virginia. C. R. Ice is superintendent and headquarters will be in Morehead, Kentucky.

● **Alex Robertson Company, 14433 Paramount Blvd., Paramount, California.** Has been awarded a contract to construct 60 miles of 20-in. from Cuyama to Ventura, California, for *Richfield Oil Corporation*, with field office in Ventura under the supervision of R. E. White and K. Pratt.

● **Rosson-Richards Processing Company, P. O. Box 908, Corpus Christi, Texas.** Has been awarded a contract by *Tennessee Gas Transmission Company* to clean and paint 200 miles of 30-in. in Wisconsin, with headquarters at Oak Creek under Elton Hood, superintendent. Also has been awarded a contract by *Trunkline Gas Company* to enamel and concrete-coat approximately 56 miles of 12, 14, and 16-in. pipe at the Delta Shipyard in New Orleans, Louisiana, with T. L. McPherson as superintendent; and a contract received from *Williams Brothers Company* to enamel and concrete-coat approximately 6660-ft of 24-in. at East Dubuque, Illinois, with McPherson as superintendent.

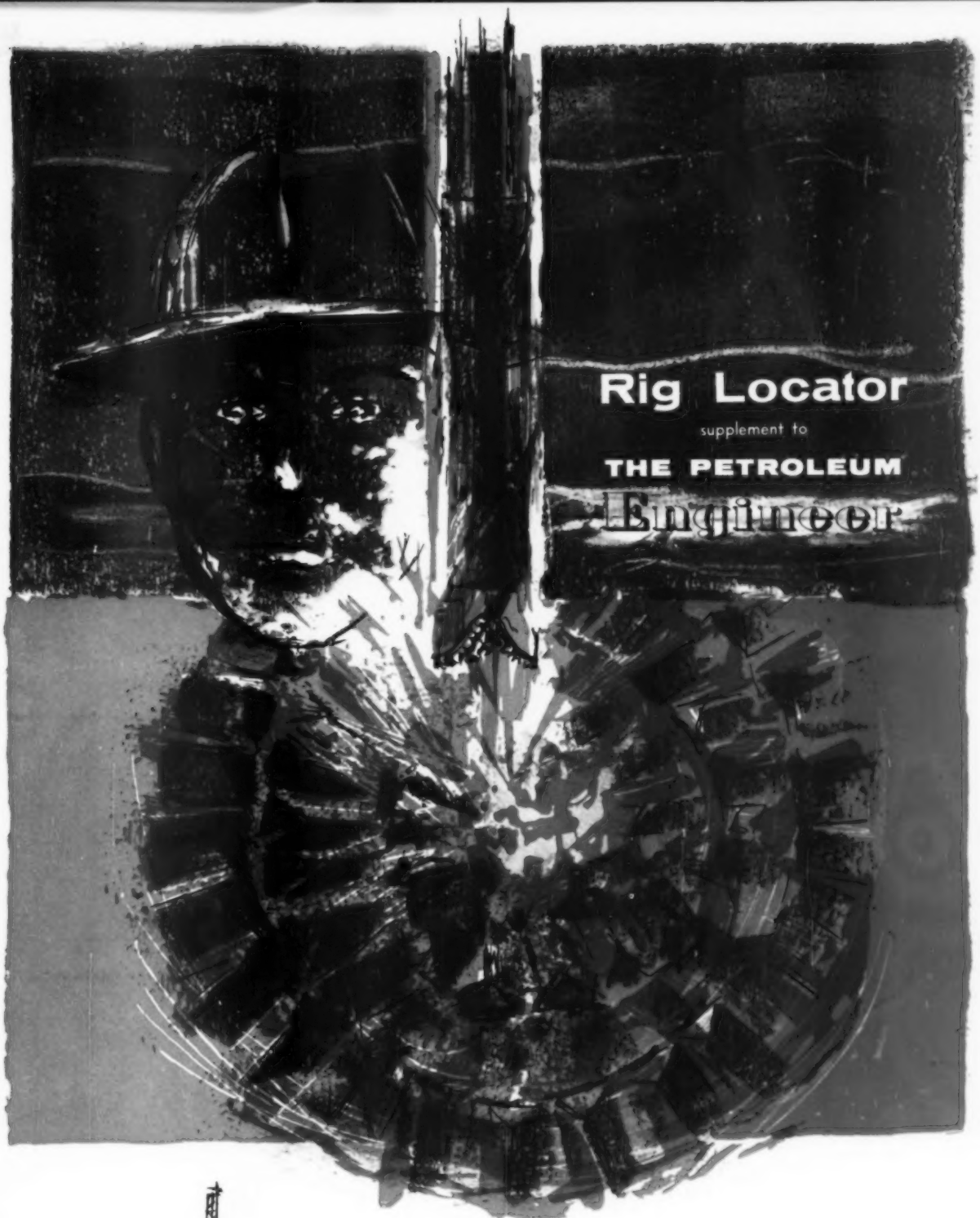
● **Shamrock Construction Company, P. O. Box 1177, Lansing, Michigan.** Has received a contract from *Ohio Fuel Gas Company* to lay approximately 30 miles of 18 through 24-in. line in various locations in Ohio; and a contract from *Dow Chemical Company* in the vicinity of Midland, Michigan, for approximately 60 miles of 2, 4, 12, and 20-in. pipe.

● **Sharman, Allen, Gay & Taylor, Inc., 3115 Buffalo Drive, Houston, Texas.** Has been awarded contract by *Freeport Sulphur Company* to lay approximately 33,000 ft of pipeline in south Louisiana. Field office for the latter job is Grand Isle, Louisiana, and spreadman is Chester Lake. Also has been awarded a contract by *United Gas Pipe Line Company* to lay approximately 14 miles of 10-in. pipeline across Galveston Bay from San Leon to Umbrella Point, Chambers County, Texas. Field office will be at Baytown and spreadman will be T. L. Plake.

● **Somerville Construction Company, 6648 Fulton Road, Ada, Michigan.** Has been awarded a contract by *Michigan Wisconsin Pipe Line Company* to construct 38.2 miles of 24-in. pipeline in Michigan. Harold Cook is superintendent and field office is located at Allegan, Michigan.

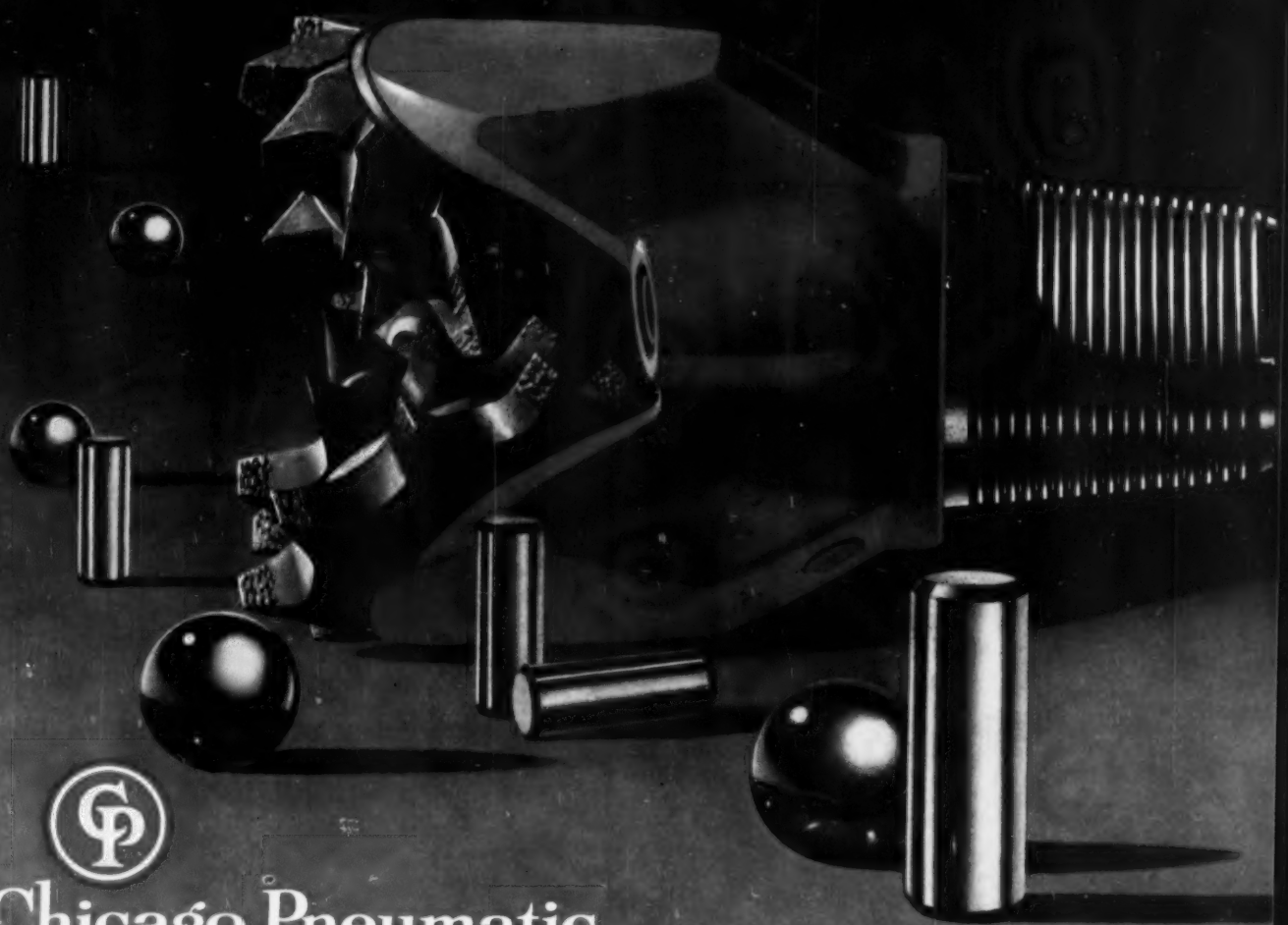
● **Western Pipe Line, Inc., P. O. Box 1076, Austin, Texas.** Has been awarded a contract by *Texas Gas Transmission Corporation* to lay 8.72 miles and 10.03 miles of 26-in. loops in Kentucky, where field office will be located at Cloverport, under John R. Wells, spreadman; and to lay 9.49 miles and 9.23 miles of 30-in. loops in Mississippi, where field office will be located at Shaw under Aldress Kilgore, spreadman. Also has been awarded a contract to lay 72 miles of pipeline for *Tennessee Gas Pipeline Company* from near Glasgow to Stanford, Kentucky.

● **Williams Brothers Company, National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has received a contract from *Consumers Power Company* to construct 40 miles of 24-in. pipeline from Woodbury to Laingsburg Junction, Michigan. Has been awarded a contract by *United Gas Pipe Line Company* to lay 49 miles of 30-in. from Lirette, Louisiana, to Lake Pontchartrain, with field office at Raceland, under O. R. Mitchell, superintendent; also a contract to lay 20 miles of 20-in. for *Louisville Gas and Electric Company* from Muldraugh to Louisville, Kentucky, where field office is located, with Earl Saulsman as spreadman; 15 miles of 20-in. in Iowa, 3 miles of 20-in. in Illinois, and 6660 ft of 24-in. across the Mississippi River for *Northern Natural Gas Company*, with field office at Dubuque, Iowa; and 45 miles of 20-in. from Mt. Seneca to Terra Alta, West Virginia, for *Atlantic Seaboard Corporation*, under Thelmer Davis, superintendent. Also has been awarded a contract by *Tennessee Gas Pipeline Company* to construct 70 miles of line from Portland, Tennessee, to near Glasgow, Kentucky.



The 12th edition of this exclusive summary of contract drilling rigs . . . both rotary and cable tool . . . and well servicing units of all types includes contractors name and address. Well servicing section covers workover rigs, pulling and servicing units.

BIGGEST BEARINGS IN THE BUSINESS



Chicago Pneumatic

FORT WORTH, TEXAS

TOOL JOINTS

THREE CONE BITS

REAMERS

Cost-cutting Performance

30 YEARS OF SERVICE TO THE PETROLEUM INDUSTRY

DRILL COLLARS

REAMING BITS

The Petroleum Engineer's July 1959

DRILLING RIG LOCATOR

Including U. S. and Canadian Well Servicing Units

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DRILLING RIG LOCATOR

Healthiest rig listing ever indicated . . . more new rigs . . . rise in horsepower ratings, auxiliary equipment . . . significant well servicing increase

The Summer 1959 issue of the RIG LOCATOR is something to "crow about." Despite the usual summer lull in activity, contractor response has been large, fast and spontaneous.

On the basis of new rig listings — upgraded listings of existing drilling, workover and well servicing equipment— the industry is in the healthiest position witnessed in the LOCATOR's 12-edition history!

There have been virtually no "going out of business" and "all rigs stacked" replies. This is in contrast to response to issues not long past.

Rotary drilling rig activity in the U. S. and Canada is surpassing marks set three years ago. By noting significant purchases of new equipment listed by the contractors in the RIG LOCATOR, it can be safely assumed that these increases are not merely "spurts"—but a return of stability of activity and operation within the industry.

Also registering much new equipment, more well servicing contractors are acknowledging the worth of this PETROLEUM ENGINEER service. In this issue, 183 additional well servicing units are included. Truly, this segment of the industry may be called "service," in that many contractors are listing many more versatile units capable of drilling, workover and other functions.

On the offshore scene, a more optimistic note is being sounded, as reflected in the increased number of active rigs. Of the contractors listing offshore units in the Summer RIG LOCATOR, only six rigs do not list an operator, signifying active status. Compared with the Spring edition, 14 rigs were without contracts. Increased West Coast offshore activity is indicated by the movement of four new rigs into the region; these additions report high horsepower ratings for deep drilling—all 1700 hp and above.

Free Service

For more than four years, The PETROLEUM ENGINEER has successfully compiled — for each four-month period — the most complete and authoritative rig information available. Its success lies in that the RIG LOCATOR: (1) Lists only data given by the contractor — the one who knows the equipment best, and (2) it gets results! The PETROLEUM ENGINEER has on record reports of actual contracts awarded via the LOCATOR. The rig data is furnished for publication, at no cost whatsoever to the contractor, issue after issue. This service has been possible only through his acceptance and continued participation.

Use of Abbreviations

In a directory of this type where certain specifications are included, it was necessary in the conservation of space to make some abbreviations. Under the column of "type power," the following abbreviations apply: Dsl for diesel; gaso for gasoline; stm for steam; btne for butane; and dsl elec for diesel electric. In listing drawworks make and model number, it was necessary to abbreviate the manufacturer's name. Some of these abbreviations are well-known; others had to be made to fit the available space. Here's the code we used:

Manufacturer's Company Name	Abbreviation
ALCO Products, Inc. (formerly Beaumont Iron Works Div. of American Locomotive Co.)	ALCO-BIW
Allis-Chalmers Manufacturing Co.	Allis Chmrs
American Iron & Machine Works	Amer
Ansaldo	Ansaldo
Bethlehem Supply Co.	Beth
Big Four Machine & Supply Co.	Big Four
Border Foundry & Machine	Border
The Brewster Co., Inc.	Brwstr
Bucyrus-Erie Co	B Erie
Cardwell Manufacturing Co., Inc.	Crdwll
Clark Bros. Co., Inc.	Clark
Fred E. Cooper, Inc.	Cooper
Continental-Emsco Co.	Emsco
Cummins Engine Co., Inc.	Cummins
George E. Failing Co.	Failing
Franks Division of Cabot Shops, Inc.	Frnks
General Machine Co.	Gen Mach
Hacker Machine & Supply Co.	Hacker
Hopper Machine Works, Inc.	Hopper
Houston Tool Co.	Hou
Howard-Turner Machine Works	Howard-Turner
Ideco, Inc.	Ideco
Ingersoll-Rand Co	Ingersoll
Jones, Shelburne & Guffey Co.	JS&G
Joy Manufacturing Co.	Joy
Lucey Export Corp.	Lucey
Mayhew Supply Co., Inc.	Mayhew
Mid-Continent Supply Co.	M-CSCO
Lee C. Moore Corp.	L. C. Moore
Muskogee Iron Works	MIW
The National Supply Co.	Natl
Oil Well Supply Division (U. S. Steel Corp.)	"Oilwell"
Reich Bros.	Reich
Spencer-Harris Machine & Tool Co.	Spencer
Stardrill-Keystone Co.	Star
Texas Iron Works, Inc.	TIW
Vickers, Inc.	Vickers
Victoria Machine Works	Vic
Wagner-Morehouse, Inc.	Wgnr-Mrhse
Walker-Neer Manufacturing Co., Inc.	Wlkr-Nr
Waldrip Engineering Co.	Wldrp
Well Machinery & Supply Co., Inc.	Ft Wrth
Wheeling Machine Products Co.	Wheeling
The Wheland Co.	Whlnd
Wichita Tool Supply Co.	Wich
Wichtex Machinery Co., Inc.	Wichtex
Wilson Manufacturing Co., Inc.	Wlsn

U. S. Rotary Drilling Contractors

A

Akin & Dimock 714 Holliday St Wichita Falls Tex
Alan Drlg Co 807 Oil & Gas Bldg Wichita Falls Tex
Thomas H Allan 925 Union Center Wichita 2 Kans
Allen & Morris Drlg Co 820 Alamo Natl Bldg San Antonio 5 Tex
Allied Expl Co 207 Huff Bldg Wichita Falls Tex
Anderson Drlg Co 730 Wichita Natl Bk Bldg Wichita Falls Tex
An-Son Drlg Co 3814 N Santa Fe Oklahoma City 18 Okla
Appell Petroleum Corp Drawer 330 Alice Tex
Arapahoe Drlg Co 1020 Petroleum Club Bldg Denver Colo
Armstrong & Horn Drlg Co 640 Milam Bldg San Antonio 5 Tex
Arrow Drlg Co 407 Philtower Bldg Tulsa 3 Okla
Ashby Drlg Co Ltd 738 Meadows Bldg Dallas 6 Tex

B

B B M Drlg Co 673 San Jacinto Bldg Houston 2 Tex
B J & M Drlg Co Ltd 160 Fairfax Ave Los Angeles Calif
B-M Drlg Co Inc Box 5218 Bossier City La
Pernie Bailey 2309 Sage Rd Houston 19 Tex
Baker & Taylor Drlg Co 712 First Natl Bk Bldg Amarillo Tex
Dorris Ballew Inc Box 561 Natchez Miss
Barnes Core Drlg Co 1350 Roberts Ln Bakersfield Calif
Barnwell Drlg Co Inc Box 1748 Shreveport La
Barrett Petroleum Co 423 Masonic Bldg Shawnee Okla
Barry Well Drlg Co West Star Rt Fallon Nev
Bass Drlg Co 905 San Jacinto Bldg Houston 2 Tex
Robert M Bass Drlg Contr Box 471 Kilgore Tex
Bateman Drlg Co 420 Saratoga Bldg New Orleans La
Bay City Drlg Co Inc Box 1389 Bay City Tex
Beard & Walker Drlg Co Box 562 Tahoka Tex
Beardmore Drlg Co 827 Beacon Bldg Wichita Kans
Beckman Inc Box 1524 Muskogee Okla
Bennett & Roberts Drlg Co Drawer 633 Russell Kans
Bernhardt Drlg Co 2469 Grand River Detroit 1 Mich
Berry Drlg Co Box 67 Saint Jo Tex
L E Bever Drlg Co 1700 W Louisiana Midland Tex
Big Chief Drlg Co Box 8837 Oklahoma City 14 Okla
Big Horn Drlg Co Inc 117 N Beech Casper Wyo
Big Seven Drlg Co 311 Wright Bldg Evansville 8 Ind
Big "6" Drlg Co 225 Oil & Gas Bldg Houston 2 Tex
Big West Drlg Co 1505 Oil & Gas Bldg Ft Worth 2 Tex
Big X Drlg Co Inc 2905 First Natl Bldg Oklahoma City Okla
Black Drlg Co 525 Petroleum Bldg Abilene Tex
Forest Blackstock Inc V & J Tower Bldg Midland Tex
Boyd & Durst Drlg Contr Box 329 Alice Tex
Brannon & Murray Drlg Co Box 672 Coleman Tex
Branyan Drlg Co Box 166 Cushing Okla
D J Branyan Co Box 166 Cushing Okla
C E Brehn Drawer 618 Mt Vernon Ill
Brewster-Bartle Drlg Co Inc 1919 Bk of Southwest Bldg Houston Tex
Brinkerhoff Drlg Co 870 Denver Club Bldg Denver 2 Colo
Zach Brooks Drlg Co Box 31 El Dorado Ark
Brown & Martin Drlg Co Box 731 Gainesville Tex
Bryant-Hayward Drlg Co Box 4627 Oklahoma City Okla
Harry T Bryant Drlg Co Ltd Box 13364 Houston 19 Tex
Brantly Drlg Co Inc Box 4935 Midland Tex
Brantly Drlg Co (Intl) Inc Box 4935 Midland Tex
Bueno Drlg Co 207 Continental Oil Bldg Denver Colo
Buick Drlg Inc 409 Wolcotte Bldg Hutchinson Kans
A O Bullock Drlg Co Box 821 Casper Wyo
Burnham & Robinson Drlg Co 4045 N Market St Shreveport La
Burton Drlg Co 239 Mellie Esperson Bldg Houston 2 Tex
Butler-Johnson Inc Box 306 Shreveport La
B G Byars Power Drlg Co 319 Citizens Bk Bldg Tyler Tex

C

C N P Drlg Co 514 Staley Bldg Wichita Falls Tex
Calco Drlg Co 1113 Continental Bk Bldg Ft Worth Tex
Calvert Drlg Inc Natl Bk of Tulsa Bldg Tulsa Okla
Camay Drlg Co 4250 Wilshire Blvd Los Angeles 5 Calif
Camay Drlg Co Rocky Mt Div Suite 1130 Denver Club Bldg Denver Colo
Camden Drlg Co Box 1418 Corpus Christi Tex
Camdrill International Inc c/o Camay Drlg Co 4250 Wilshire Blvd Los Angeles 5 Calif
Canadian River Drlg Co 424 Petroleum Bldg Amarillo Tex
Capitan Drlg Co Inc Box 671 Odessa Tex
Frank Caraway Drlg Co Box 982 San Angelo Tex
Carmack Drlg Co 1700 Broadway Denver Colo
Carpenter-Trant Drlg Co 321 C A Johnson Bldg Denver 2 Colo
Carper Drlg Co Inc Box 905 Hobbs N M
Carroll Drlg Co Inc Box 337 Farmington N Mex
Carter-Jones Drlg Co Box 1597 Kilgore Tex
Chiles Drlg Co Box 949 Alice Tex
Choya Drlg Co Inc 500 W Illinois Midland Tex
Circle Drlg Co Inc 620 Pioneer Bldg Lake Charles La
Clark Drlg Co Box 1743 Billings Mont
Dan L Clark Drlg Co 819 Wilson Tower Corpus Christi Tex
Claypool Drlg Co Box 98 St Elmo Ill
Clinch Drlg Co Box 27 Hazlehurst Miss
Coastal Drlg Co 7300 Downing Ave Bakersfield Calif
Columbia Drlg Co 1207 C & I Life Bldg Houston 2 Tex
Comet Drlg Co Box 1143 OCS Lafayette La
Conrey Drlg Co 328 E Broadway Centralia Ill
Continental Marine Expl Co Box 3050 Houston Texas
Continental Shelf Drlg Corp 916 Richards Bldg New Orleans 12 La
Coroco Drlg Co 2000 Mercantile Bk Bldg Dallas 1 Tex
Jess P Cross Drlg Contr 1216 Texas St Graham Tex
Crow Drlg & Prod Co 2000 Beck Bldg Shreveport La
Crown Rigs Inc 2107 Bk of the Southwest Bldg Houston Tex
Sam E Crump Drlg Co 2404 Rankin Hwy Midland Tex

D

D & M Drlg Co Inc Box 247 Great Bend Kans
Danforth Drlg Co 418 Kennedy Bldg Tulsa Okla
R W Darden Drlg Co Box 576 Olney Tex
Davidson Drlg Co Inc 1004 Continental Life Bldg Ft Worth Tex
Davis & Bates Inc 1601 Milam Bldg San Antonio 5 Tex
Edgar Davis Drlg Co 717 Citizens Bk Bldg Abilene Tex
Harvey Davis & Robt H Thompson Co 1731 28th St Bakersfield Cal
Davon Drlg Co Box 1586 Oklahoma City 9 Okla
M J Delaney Co 910 Dallas Fed Savings Bldg Dallas 1 Tex
Delta Drlg Co Box 2012 Tyler Tex
Delta Overseas Drlg Co (Rome Italy) Box 2012 Tyler Tex
The Denver Co 1904 Great Plains Life Bldg Lubbock Tex
Dillard-Waltermire Inc 109 Oil & Gas Bldg Houston 2 Tex
R V Dillard Drlg Co Box 992 Duncan Okla
W L Dillier Box 341 Casey Ill
Dixon Drlg Co Box 2320 Abilene Tex
Doak Drlg Co Box 1108 Bristow Okla
Douglas Drlg Co Box 1267 OCS Lafayette La
Drillers Inc 2005 Adolphus Tower Dallas Tex
Drlg & Expl Co Inc Box 35366 Dallas 35 Texas
Drlg & Expl Co of Delaware Inc 35366 Dallas 35 Tex
Drilling & Production Co 2907 L St Bakersfield Calif
Dual Drlg Co 606 City Natl Bk Bldg Wichita Falls Tex
Dudley & Heath Drlg Co Box 428 Stillwater Okla
Durham Drlg Co Inc Box 204 Midland Tex

E

E & H Drlg Co Box 1058 Graham Tex
E L & M Drlg Co Box 813 Holdenville Okla
Eakle & Holder Drlg Co 116 Mulberry St Evansville Ind
T T Eason Co Div of Eason Oil Co Box 9755 Oklahoma City 18 Okla
Eastland Drlg Co 806 Continental Life Bldg Ft Worth 2 Tex
King Edwards (Edwards Drlg Co) Box 1140 Graham Tex
A W Eggleston Inc Box 425 Crowley La
Eilers Drlg Co Box 169 New Iberia La
Ellis 1536 Austin St Colorado City Tex
Empire Drlg Co 1403 Texaco Bldg Dallas 1 Tex
Empire Drlg Co 650 Fourth Natl Bk Bldg Wichita 2 Kans
Empire States Drlg Corp 1020 Simms Bldg Albuquerque N M
Exeter Drlg Co Republic Natl Bk Bldg Dallas 1 Tex
Exploration Drlg Co 607 Natl Bk of Tulsa Bldg Tulsa Okla

F

Fairman Drlg Co Hammersley Fork Pa
Falco Drlg Co Inc Box 1255 Alice Tex
Field Drlg Co 1901 Milam Bldg San Antonio Tex
Jim Fish Drlg Co Box 655 Iowa Park Tex
Fitzpatrick Drlg Co 803 Wilson Tower Corpus Christi Tex
J B Fletcher Drlg Co 306 Ricou-Brewster Bldg Shreveport La
Foree Drlg Co 607 First Natl Bk Bldg Dallas 2 Tex
Fortenbery Drlg Co Inc Box 273 Natchez Miss
C J Foster Drlg Co Inc Box 657 Richmond Tex
Frank Frawley Drlg Co 823 S Detroit Tulsa 3 Okla
Lloyd R French Co 506 V & J Tower Midland Tex
Frio Drlg Inc 506 Driscoll Bldg Corpus Christi Tex
Frizzell Drlg Co 108 NW 2nd St Oklahoma City Okla
Frontier Drlg & Prod Co 216 Petroleum Life Bldg Midland Tex
Fryer & Hanson Drlg Co 2520 Republic Natl Bk Bldg Dallas Tex

G

Tine Gaiser Drlg Co Box 1506 Bakersfield Calif
Gardner Bros Drlg Co Inc 1718 Davis Bldg Dallas Tex
Garr-Woolley Oil Co 901 Cravens Bldg Oklahoma City Okla
Gary Drlg Co Box 58 Oil City La
General Drlg Co P O Box 1845 Oklahoma City 1 Okla
General Geophysical Co 750 Houston Club Bldg Houston 2 Tex
General Well Drlg Inc Box 1315 Alice Tex
Clyde Gibson Drlg Co 712 City Natl Bk Bldg Wichita Falls Tex
Glenn Gillespie & Sons Box 907 Cushing Okla
Glendale Drlg Co 906 Hales Bldg Oklahoma City Okla
Glenn Drlg Co 38 Kennedy Bldg Tulsa Okla
F E Gober Drlg Co 3032 Cherry Ave Long Beach 7 Calif
Goff-Leeper Drlg Co Box 1749 Ardmore Okla
Gore Drlg Co Box 515 Albany Tex
T V Gorman Drlg Contr 621 Staley Bldg Wichita Falls Tex
H O Grace Drlg Co 632 Wichita Natl Bldg Wichita Falls Tex
Jack Grace Drlg Co 1009 City Natl Bldg Wichita Falls Tex
Gracey-Hellums Corp 410 S Coast Bldg Houston 2 Tex
Graham Drlg Co 2nd Floor First St Bk Bldg Temple Okla
Graham & Klassen Drlg Co Inc 4715 Crenshaw Blvd Los Angeles Calif
Graham-Michaelis Drlg Co 211 N Broadway Wichita 2 Kans
John Grappe Drlg Co Box 1186 Levelland Tex
Gray Drlg Co 220 Wichita Natl Bldg Wichita Falls Tex
Graytex Drlg Co 406 Robertson Bldg Wichita Falls Tex
Great Western Drlg Co Box 1659 Midland Tex
Green & Drebiow Drlg Co Box 1057 Bakersfield Calif
Grey Wolf Drlg Co 1506 Bk of the Southwest Houston 2 Tex
Guadalupe Drlg Co 2505 Princeton Ave Midland Tex
Roy Guffey Drlg Co 5543 Yale Blvd Dallas 6 Tex
Gulf Coast Drlg & Expl Inc Box 2367 Choctaw Sta Laurel Miss
Henry Gwaltney Drlg Co 19 NE Third St Washington Ind

H

H & S Drlg Co 407 Tri State Ins Bldg Tulsa Okla
Hack Drlg Co Box 5108 Abilene Tex
John S Hagestad Drlg Co 3224 Gulf St Bakersfield Calif
Halbert Drlg Co 607 Citizens Bk Bldg Tyler Tex
Clyde Hall Drlg Co Inc Box 4068 Bakersfield Calif
O E Hall Drlg Co 2008 Continental Natl Bk Bldg Ft Worth 2 Tex
Hamilton Investment Co 1220 Hamilton Bldg Wichita Falls Tex
Hamilton-Powell Drlg Co Inc 1220 Hamilton Bldg Wichita Falls Tex
Hamman Oil & Ref Co Box 13028 Houston 19 Tex
Haney & Williams Drlg Co 3500 Cherry Ave Long Beach 7 Calif
Haney-Williams Drlg Corp S A 3500 Cherry Ave Long Beach 7 Calif
Hap Drlg Co 2510 First Natl Bldg Oklahoma City Okla
F E Hargraves & Sons Drlg Co Inc Box 573 Oil City La
Harkins & Co Box 1490 Alice Tex
Dave Harlin Drlg Co 107 Bramfield Bldg Snyder Tex
Harper-Turner Drlg Co 904 Hightower Bldg Oklahoma City Okla
Harris Drlg Co Box 699 Grayville Ill
John W Harris Drlg Co 525 Wichita Natl Bk Bldg Wichita Falls Tex
Harvey Drlg Co Box 418 Wichita Falls Tex
John Haseman Inc 419 Wilson Bldg Corpus Christi Tex
J W Hastings Drlg Co 722 Wichita Natl Bk Bldg Wichita Falls Tex
Hawkins-Wilkins Prod Co 373 San Jacinto Bldg Houston 2 Tex
Win Hawkins Drlg Co 373 San Jacinto Bldg Houston 2 Tex
Hayes & Sprague Inc 612 S Flower Los Angeles Calif
Hayward Drlg Co Box 295 Enid Okla
Helmerich & Payne Inc First Natl Bldg Tulsa Okla
Henson Drlg Co Box 2192 Abilene Tex
The Herb Expl Co 342 Lexington Ave Abilene Tex
Herndon Drlg Co Drawer 489 Tulsa Okla
Maxwell Herring Drlg Corp 619 Citizens Bk Bldg Tyler Tex
B M Hester Box 2588 Wichita Falls Tex
Hewgley Drlg Co 704 Wilco Bldg Midland Tex
Hewit-Gulick Drlg Co 2555 1st Natl Bk Bldg Denver 2 Colo
Hilburn Industries Inc Ricou-Brewster Bldg Shreveport La
J E Hillier Box 67 Pleasanton Tex
W B Hinton 2900 Mercantile Bk Bldg Dallas 1 Tex
Holliman Drlg Co 712 Fidelity Union Life Bldg Dallas Tex
Holm Drlg Co Box 7246 Tulsa 18 Okla
Holmes Drlg Co 1045 San Jacinto Bldg Houston Tex
Hondo Drlg Co Box 116 Midland Tex
R L Horn & Son Drlg Co Pawnee Okla
Hose-Austin Drlg Corp Box 1067 Casper Wyo
Houchins Drlg Co Box 388 Mt Carmel Ill
Hull Oil Co 214 Panhandle Bldg Wichita Falls Tex
Hunt Drlg Co Inc 633 Wilson Bldg Corpus Christi Tex

I

Indian Drlg Co Box 42 Tulsa Okla
Donald T Ingling 623 First Natl Bk Bldg Wichita 2 Kans
Isern Drlg Co Box 45 Ellinwood Kans
Ivy Drlg Co 1705 Burton Way Bakersfield Calif

J

J & C Drlg Co 311 Citizens Standard Bldg Corpus Christi Tex
S W Jack Drlg Co Allegheny Ave Avonmore Pa
Tom Jack Drlg Co Box 288 Sulphur Okla
A L Jackson Drlg Co Box 194 Great Bend Kans
Jett Drlg Co Inc Box 1832 Shreveport La
Johnn Drlg Co 711 Fair Bldg Ft Worth 2 Tex
Johnson-Bates Drlg Co Box 425 Konawa Okla
Johnson Drlg & Serv Co Box 3 Magnolia Ark
Al Johnson Drlg Co Rt 12 Box 440 Oklahoma City 15 Okla
Jonco Drlg Co Box 1214 Seminole Okla
J E Jones Drlg Co Box 1516 Midland Tex
Woody Jones Drlg Co 408 E Main St Olney Ill

K

K & E Drlg Inc 719 Union Center Bldg Wichita 2 Kans
K L Kellogg & Sons 3777 Long Beach Blvd Long Beach 7 Calif
Kelly Drlg Co Inc Box 1126 Houma La
Kendall-Davis Drlg Co Inc 201 S E 1st St Evansville Ind
Kendrick Bros 121 E Louisiana St Vivian La
Kent Drlg Co Box 2555 Salt Lake City Utah
Kermac Drlg Co Kerr-McGee Bldg Oklahoma City Okla
Kermac Drlg Co of Venezuela Kerr-McGee Bldg Oklahoma City Okla
Kerr-McGee Oil Industries Inc Kerr-McGee Bldg Oklahoma City Okla
King-Phillips Inc 1109 Continental Natl Bk Bldg Ft Worth Tex
Kingery Drlg Co Inc Box 97 Saint Jo Tex
Kirby Oil Ind Inc 5107 Center St Omaha 6 Neb
Kirkpatrick Oil Co 1300 N Broadway Oklahoma City Okla
Knight Drlg Co Box 1332 Bakersfield Calif

L

L & F Drlg Co Box 1468 Bakersfield Calif
L & J Drlg Ltd 320 Indiana Bk Bldg Evansville Ind
L & N Drlg Co 6709 Canal Blvd Shreveport La
Lake Drlg Co 1417 Church St Beaumont Tex
La Mance Drlg Co Box 4457 Midland Tex
Latexo Drlg Co Inc 2212 Adolphus Tower Bldg Dallas 2 Tex
Roy Lawrence Drlg Co Box 306 Pawnee Okla
Layton and Newell Drlg Co 1505 Oil & Gas Bldg Ft Worth 2 Tex
Layton Brown Drlg Co Box 185 Woodsboro Tex
Leatherwood Drlg Co Box 925 Jacksboro Tex
Lewis Bros Inc Suite 310 1700 Broadway Denver 2 Colo
Will I Lewis Drlg Co 207 Continental Oil Bldg Denver Colo
Lincoln Drlg Co 403 Oil & Gas Bldg Oklahoma City Okla
Ted Lindsay Box 190 Mt Vernon Ill
M M Lindsey Drlg Co Box 3055 Baton Rouge La
Lin-Mour Drlg Co 1112 Oil & Gas Bldg Wichita Falls Tex
Llano Drlg Co 301 V & J Tower Bldg Midland Tex
Lohmann-Johnson Drlg Co Inc 320 Indiana Bk Bldg Evansville Ind
Lohmann-Johnson Oil Co Inc 320 Indiana Bk Bldg Evansville Ind
Longhorn Drlg Corp Box 546 Three Rivers Tex
Love-Miller Drlg Co Inc 712 Patterson Bldg Denver 2 Colo
Low Drlg Co Box 1112 Cisco Tex
Lowe Drlg Co Box 832 Midland Tex
Lynn Drlg Co 1403 Natl Bk of Tulsa Bldg Tulsa Okla

M

Mac Drlg Co Box 2972 Houston Tex
Mallard Drlg Co 1016 Union Natl Bk Bldg Wichita Kans
Manonee Drlg Co Inc 820 Union Center Wichita Kans
Mangum Drlg Co 834 Esperson Houston Tex
Marcum Drlg Co Box 761 Ada Okla
Marine Drlg Inc 614 Whitney Bk Bldg New Orleans La
Maritzky & Bibby Box 509 Homer La
Lubie Martin Drlg Co 2052 Harvard Houston Tex
Mast Drlg Inc Box 33 Russell Kans
Maxwell Drlg Co Box 846 Coleman Tex
M Mazzarino 104 W Broadway Centralia Ill
Gabe McCall Drlg Co Box 2068 Casper Wyo
McCalman Drlg Co Inc Box 602 Homer La
Gene McCutchin Drlg Co Box 1585 Dallas Tex
McDaniel Drlg Co 205 C A Johnson Bldg Denver 2 Colo
McDaniel & Beecherl Drlg Co 908 Dallas Fed Sav Bldg Dallas 1 Tex
McKenzie Drlg Co 837 Wilson Bldg Corpus Christi Tex
McQueen & Stout Drlg Co 1113 Ft Worth Natl Bk Bldg Ft Worth 2 Tex
Meadows & Walker Drlg Co 500 San Jacinto Bldg Houston 2 Tex
Melco Drlg Co Box 1360 Seminole Okla
Meredith & Co 1418 Bk of the Southwest Bldg Houston 2 Tex
Meredith Drlg Co 419 City Natl Bldg Wichita Falls Tex
Mesker Drlg Co 1129 E 15th St Tulsa Okla
M-H-O Drlg Co Box 297 Cut Bank Mont
Midland Drlg Co 410 W Ohio Midland Tex
Midwestern Drillers Inc 1206 Mid-Continent Bldg Tulsa 3 Okla
Milam Drlg Co 1814 Alamo Natl Bldg San Antonio Tex
Milestone Drlg Co Box 314 Midland Tex
Miller & York Box 1664 Bakersfield Calif
Miller Bros & Bowling Box 611 Alice Tex
Miracle & Wooster Drlg Co Box 233 Vernal Utah
Mobile Drlg & Well Serv Co Inc Box 207 Conroe Tex
Monroe Drlg Co Inc Box 490 Monroe La
Montgomery Drlg Co Box 747 El Dorado Ark
J S Montgomery 103 NW 44th St Oklahoma City 18 Okla
Moran Bros Inc 1200 Oil & Gas Bldg Wichita Falls Tex
Moran Oil Prod & Drlg Corp Box 1718 Hobbs N Mex
E F Moran Inc 1805 Natl Bk of Tulsa Bldg Tulsa 3 Okla
E W Moran Drlg Co 500 First Natl Bk Bldg Wichita Falls Tex
Dave Morgan Drlg Co Box 820 Blackwell Okla
Pete Morris Drlg Co Box 733 Ada Okla
Dale Mount Drlg Inc 1155 Mercantile Dallas Bldg Dallas 1 Tex
Mountain States Drlg Co Inc 622 Patterson Bldg Denver 2 Colo
Murfin Drlg Co 617 Union Center Wichita 2 Kans
Murphy & McKernan Box 169 Pampa Tex

N

Neal Drlg Co 1507 Esperson Bldg Houston 2 Tex
Nemaha Oil Co Mercantile Bk Bldg Dallas Tex
Newton Drlg Co Box 1104 Coalinga Calif
The Noah Petroleum Co Box 192 Albion Ill
Norman Drlg Corp 1141 Butternut St Abilene Tex
Norton Drlg Co 542 Natl Bk of Commerce Bldg New Orleans 12 La
Norwood Drlg Co 700 Wichita Natl Bk Bldg Wichita Falls Tex
The Novak Drlg Co Box 2147 Tulsa Okla
Nuckolls-Bell Drlg Co 1255 First Natl Bldg Oklahoma City 2 Okla
Nye & Snell Drlg Co 208 Patterson Bldg Denver Colo

O

Davey O'Brien Drlg Co Inc 615 Ft Worth Club Bldg Ft Worth 2 Tex
Oien Oil Corp Box 2235 Cut Bank Mont
Olds & Wrather Drlg Co Box 113 Casper Wyo
Olds & Wrather Oil Co Box 113 Casper Wyo
R Olsen Liberty Bk Bldg Oklahoma City Okla
W B Omohundro Box 774 Wichita Falls Tex
O'Neal-Garvin Drlg Co Box 1289 Duncan Okla
Oney Drlg Co Box 425 Graham Tex
Ormand Bros Drlg Co Box 1469 Odessa Tex
O'Rourke-McGirl Drlg Co 741 Natl Bk of Tulsa Bldg Tulsa Okla
Owen Drlg Co Box 1423 OCS Lafayette La

P

Paine Drlg Co 301 Insur-O-Medic Bldg Dallas Tex
Pan-Tex Drlg Co 316 Henderson Blvd Kilgore Tex
Parker Drlg Co 418 Natl Bk of Tulsa Bldg Tulsa 3 Okla
Howard Parker Co 1103 Bk of Southwest Bldg Houston Tex
Patton Drlg Co Inc Orpheum Bldg Wichita Kans
Noel Pautsky 320 Oil & Gas Bldg Wichita Kans
Willard Pease Drlg Co Box 1532 Grand Junction Colo
Pegg Bros Drlg Co 1204 Natl Bk of Commerce Bldg San Antonio Tex
Penrod Drlg Co 1320 Mercantile Securities Bldg Dallas 1 Tex
Pep Drlg Co 1008½ Main St Mt Vernon Ill
Perforaciones Delta C A Apartado 9138 Caracas Venezuela (Box 2012 Tyler Tex)
Perkins Drlg Co Box 1232 Duncan Okla
Perrine & Perrine Drlg Contr Box 87 Salem Ill
Petersen Petroleum Corp 836 Olive Shreveport La
Petro Drlg Co Inc Box 339 Mt Vernon Ill
Petroleum Drlg Co 200 Petroleum Bldg San Angelo Tex
Pico Drlg Co Box 512 Breckenridge Tex
Pickrell Drlg Co 705 Fourth Natl Bk Bldg Wichita 2 Kans
Pierce Drlg Co 605 Oil & Gas Bldg Wichita Falls Tex
Pioneer Drlg Co Inc Box 2211 Casper Wyo
Louis Pitcock Drlg Co Box 749 Graham Tex
Pool & Gerlich Drlg Co Box 1940 San Angelo Tex
Fred Pool Drlg Co 3106 Lockheed Midland Tex
Powell Drlg Co 412 Union Center Bldg Wichita Kans
The Power Rig Drlg Co Inc Box 1436 OCS Lafayette La
Prairie Drlg Co Inc Box 2068 Casper Wyo
Prince Marine Drlg & Expl Co 434 Bk of Southwest Bldg Houston Tex
Producers Drlg Co Inc 927 Natl Bk of Commerce Bldg New Orleans La
Pyburn Drlg Co Box 4276 Shreveport La

Q

Quaker Drlg Co Inc 1100 Bitting Bldg Wichita 2 Kans

R

R-G Drlg Co 403 City Natl Bk Bldg Wichita Falls Tex
R W I T Drlg Co Box 551 Holdenville Okla
Reading & Bates Inc 1101 Philtower Bldg Tulsa 3 Okla
Reed Drlg Co Inc 1209 Atlas Bldg Tulsa Okla
Reserve Drlg Co Inc 625 Union Center Bldg Wichita 2 Kans
Rex & Morris Drlg Co Box 334 El Dorado Kans
Rheay & Reynolds Drlg Co 404 Petroleum Bldg Abilene Tex
Rhodes Drlg Co Box 239 Abilene Tex
Rhodes & Hicks Drlg Corp Box 1395 Alice Tex
Rimrock-Tidelands Inc Box 896 New Orleans La
R W Rine Drlg Co 420 Union Center Bldg Wichita Kans
C M Roberson Drlg Co 1201 Petroleum Tower Shreveport La
Robinson Bros Drlg Co Box 430 Borger Tex
Robinson-Wehmeyer Drlg Co 470 San Jacinto Bldg Houston Tex
Rocket Drlg Co 2099 E 27th St Long Beach 6 Calif
Rocky Mountain Drlg Co 6790 N Ventura Ave Ventura Calif
Roden & McRae Drlg Co Box 2286 Casper Wyo
R Benton Ross Inc 403 Robertson Bldg Wichita Falls Tex
Dwight M Ross Drlg Co 223 Hamilton Bldg Wichita Falls Tex
Don M Rounds Drlg Co Inc 925 Petroleum Club Bldg Denver 2 Colo
Rowan Drlg Co Inc Drawer 12247 Ft Worth 16 Tex
J W Rudy Box 684 Clay City Ill
Rupp-Ferguson Oil Co 522 Union Center Bldg Wichita Kans
A D Rushing Inc Box 232 Santa Paula Calif
Russell & Russell Drlg & Prod 621 Lindsay St Gainesville Tex
Rutledge Drlg Co Box 2239 Santa Fe N Mex

S

S D & S Drlg Co Inc 325 Wilson Bldg Corpus Christi Tex
Sabre Drlg Co 222 Hughes Bldg Cushing Okla
Santa Fe Drlg Co Box 310 Whittier Calif
Santa Rosa Drlg Co Box 633 Apple Valley Calif
A L Schlaikjer Box 761 Newcastle Wyo
Schoenfeld-Hunter-Kitch Drlg Co 812 Kennedy Bldg Tulsa 3 Okla
Scooter's Drlg Serv 1215 Sklar Bldg Shreveport La
Seran & Howard Drlg Co Box 110 Okemah Okla
Severns Drlg Co Ltd 639 S Spring St Suite 1119 Los Angeles Calif
Shelley-Miller Drlg Co 205 Miller Bldg Wichita Kans
Sheets & Walton Drlg Co Box 152 Breckenridge Tex
Sherin Drlg Co Inc 1709 First Natl Bldg Oklahoma City Okla
Shields Drlg Co Inc Box 709 Russell Kans
Shulman Bros Box 191 Vandalia Ill
Sikes-Burckhalter Drlg Co 300 Oil & Gas Bldg Wichita Falls Tex
Joe Simpkins 6421 Easton Ave St Louis 14 Mo
Simpson & Harris Drlg Co 2975 Wilshire Blvd Los Angeles 5 Calif
C J Simpson Drlg Co 10353 Denton Drive Dallas 20 Tex
Sitton & Norton Drlg Co 406 Lubbock Natl Bk Bldg Lubbock Tex
Don Slape Drlg Co Box 432 Olney Ill
Smiley & Little Drlg Co 1635 SE 29th St Oklahoma City Okla
B B Smith Inc Box 5103 Midland Tex

Ray Smith Drlg Co 305 Simons Bldg Dallas Tex
L C Smitherman Drlg Co Box 627 Augusta Kans
Sojourner Drlg Corp Box 679 Abilene Tex
South States Drlg Co Box 147 Longview Tex
J D Speer Box 327 Healdton Okla
J D Sprecher Box 299 Casper Wyo
Steen Drlg Co 619 West Bldg Houston 2 Tex
Stice Drlg Co Box 678 Beeville Tex
The Sun Drlg Co 2975 Wilshire Blvd Los Angeles 5 Calif
Sunnyland Contr Co Inc Box 388 Rayne La
Sutton Drlg Co Box 6446 San Antonio 9 Tex
Symons Drlg Co 999 Houston Club Bldg Houston 2 Tex

T

T & H Corp 111 N 7th S Terre Haute Ind
Target Drlg Corp 421 Mayo Bldg Tulsa Okla
Taylor Expl Co Inc 2118 Welch Ave Houston 19 Tex
W P Taylor Drlg Co 707 Hawthorne Houston Tex
Temple Drlg Co Inc 320 Indiana Bk Bldg Evansville Ind
Teton Drlg Co Ltd Box 2068 Casper Wyo
Texas Drlg Co Box 183 Monahans Tex
Texas R F O Inc 421 Meadows Bldg Dallas 6 Tex
Thomas & Billups Drlg Co 809 Citizens Natl Bk Bldg Abilene Tex
D Thomason Drlg Co Inc 1703 Beck Bldg Shreveport La
Thompson & Wathan Drlg Co R R No 1 Rte 45 N Flora Ill
Thrasher Drlg Co Inc 1602 Beck Bldg Shreveport La
Timberland Expl Co 1069 San Jacinto Bldg Houston 2 Tex
Trachta Drlg Co Box 67 Muenster Tex
J C Trahan Drlg Contr Inc 1203 Beck Bldg Shreveport La
Transit Corp 1516 Liberty Bk Bldg Oklahoma City Okla
Trant Drlg Co 1201 Peoples Bk Bldg Tyler Tex
Trio Drlg Co 3013 Nussbaumer St Dallas 26 Tex
Tri-Service Drlg Co Box 1785 Midland Tex
Triton Drlg Co Inc Box 22282 Houston 27 Tex
Troop Drlg Co Box 145 St Elmo Ill
Troup & Suttles Inc Box 551 Holdenville Okla
True Drlg Co Drawer 1612 Casper Wyo
Turnbull & Zoch Drlg Co Box 2248 Corpus Christi Tex
Turner & West Box 65 Stamford Tex
Two R Drlg Co Inc 712 South St Houma La

U

U & E Drlg Co Box 323 Sullivan Ind
Unit Drlg Co Box 599 Bristow Okla
United Drlg Co 8750 Holloway Dr Los Angeles 46 Calif

V

V S & S Drlg Co 1004 Ridgley Bldg Springfield Ill
V-T Drlg Co 711 Hulman Bldg Evansville Ind
Varner-Neill Drlg Co Box 1999 Abilene Tex
Veeder Supply & Dev Co Box 201 Cherryvale Kans
Viersen & Cochran Box 280 Okmulgee Okla
Viking Drlg Co 102 W Crockett St San Antonio 5 Tex

W

WLB Drlg Co 6635 Chocolate Bayou Rd Houston 21 Tex
Wade Drlg Co Inc 813 Gulf Bldg Tulsa Okla
Wagner & Wyant Drlg Co Inc 414 Petroleum Bldg Amarillo Tex
Earl F Wakefield 515 Union Center Bldg Wichita Kans
Walters Drlg Co 510 Orpheum Bldg Wichita Kans
Walters Drlg Co Inc 4114 McMillan Dallas 6 Tex
Rusty Walters Drlg Co Box 304 Bakersfield Calif
Walton Drlg Co Box 241 Fairfield Ill
Ward Drlg Co 106 Oil & Gas Bldg Wichita Falls Tex
Tommy Ward Drlg Co 2402 Liberty Bk Bldg Oklahoma City Okla
Travis Ward Drlg Co Box 729 Athens Tex
Warren Drlg Co 1012 Mayo Bldg Tulsa 3 Okla
Warton Drlg Co Box 2807 Odessa Tex
C B Webster Drlg Co 609 San Jacinto Bldg Houston 2 Tex
Dick Wegener Drlg Co 1820 First Natl Bldg Oklahoma City 2 Okla
Well Drillers Inc 2001 First City Natl Bk Bldg Houston 2 Tex
West Central Drlg Co 717 Citizens Bk Bldg Abilene Tex
Western Serv Drlg Co Inc Box 1428 Odessa Tex
Wes-Tex Drlg Co Box 2058 Abilene Tex
Chester H Westfall Drlg Co 1612 First Natl Bldg Tulsa Okla
Westlund Drlg Co Box 197 Midland Tex
Chet Whaley Well Serv Co Inc 6006 Milart St Houston 21 Tex
Wheless Drlg Co Box 1746 Shreveport La
Wilbanks & Rutter Drlg Co 2200 Scurry St Big Spring Tex
A W Williams Drlg Co Inc General Delivery Mobile Ala
Walter W Willis 813 Broadway Mt Vernon Ill
Fred Wilson Drlg Co 1604 Beck Bldg Shreveport La
W W Wise Drlg Inc Box 297 Tyler Tex
Woodson Prod Co 412 Exposition Dallas 26 Tex
Woolf & Magee Inc Box 635 Tyler Tex
Wright Clark & Senkel Inc Box 267 Graham Tex

Y

S P Yates Drlg Co 311 Carper Bldg Artesia N Mex
Marshall R Young Drlg Co Drawer 712 Brookhaven Miss

U. S. Contract ROTARY Drilling Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ALABAMA						
CLARKE COUNTY						
A W Williams Drlg Co Inc	2	dsl	495	Frnks 6000	495	8500/4"
MOBILE COUNTY						
Zach Brooks Drlg Co	3	dsl	900	Brwstr N-7	900	8,500
Drlg & Expl Co of Del Inc	23	gas-gaso	1000	Natl 100	900	12,000
Jett Drlg Co Inc	104	dsl	1250	Brwstr N-75	1000	12,000
	109	gas-gaso	1000	Brwstr N-7	800	9,500
Sunnyland Contr Co Inc	11	dsl	–	Ideco H-750	520	11,000
	14	dsl	1800	Beth Tornado	1200	16,000
ALASKA						
Mountain States Drlg Co Inc	15	gas-dsl	1400	Natl 125	–	15,000
KENAI PENINSULA						
Coastal Drlg Co	3	dsl	1000	Emsco A-800	1650	13,000
	5	dsl	1950	Emsco GB-800	1300	14,000
ARIZONA						
APACHE COUNTY						
Rutledge Drlg Co	4	gas-btne	500	Beth C-50	675	8,000
ARKANSAS						
CALION COUNTY						
F E Hargraves & Sons Drlg Co	3	btne	185	Brwstr W-50	185	2800/3-1/2"
COLUMBIA COUNTY						
Arrow Drlg Co	16	gas-elec	840	Emsco	–	10,000
L & N Drlg Co	2	btne	226	Wlsn Super	110	2,500
Montgomery Drlg Co	2	gas-btne	415	Brwstr N-55	–	7,500
CRAWFORD COUNTY						
Parker Drlg Co	5	gas	–	Natl 50	700	9,000
INDEPENDENCE COUNTY						
Walters Drlg Co Inc	4	gas	130	Mayhew 1000	130	600/2-3/8"
LAFAYETTE COUNTY						
McCalman Drlg Co Inc	1	dsl	–	Brwstr N-4	300	5,500
LITTLE RIVER COUNTY						
Walters Drlg Co Inc	5	gas	150	Mayhew 1000	150	600/2-3/8"
SALINE COUNTY						
Walters Drlg Co Inc	8	gas	220	Mayhew 1000	220	600/2-3/8"
UNION COUNTY						
L & N Drlg Co	1	btne	260	Brwstr N-3	185	3,500
CALIFORNIA						
COLUSA COUNTY						
B J & M Drlg Co Ltd	1	dsl	600	M-CSCO U-35D	400	7,000
Rusty Walters Drlg Co	1	dsl	300	Cooper D-50	300	6,500/4"
CONTRA COSTA COUNTY						
L & F Drlg Co	3	gas-dsl	1000	Natl 75	–	9,800
FRESNO COUNTY						
Camay Drlg Co	2	gas	1080	Wlsn Titan	1000	12,000
Hayes & Sprague, Inc.	1	gas	1050	Wlsn Titan	1050	13,000
Newton Drlg Co	1	dsl	300	Ideco H-30	300	4,000
	2	dsl	500	Ideco H-40	320	5,000
GLENN COUNTY						
Rusty Walters Drlg Co	1	dsl	300	Wlsn Mogul	300	7,000/4"
KERN COUNTY						
B J & M Drlg Co Ltd	3	gas	450	Natl 50	775	8,500
Barnes Core Drlg Co	D-10	dsl	450	Custom	450	5500/3½"
	D-11	dsl	225	Custom	225	3000/3½"
Camay Drlg Co	1	gas	1075	Emsco J-1000	1000	12,000

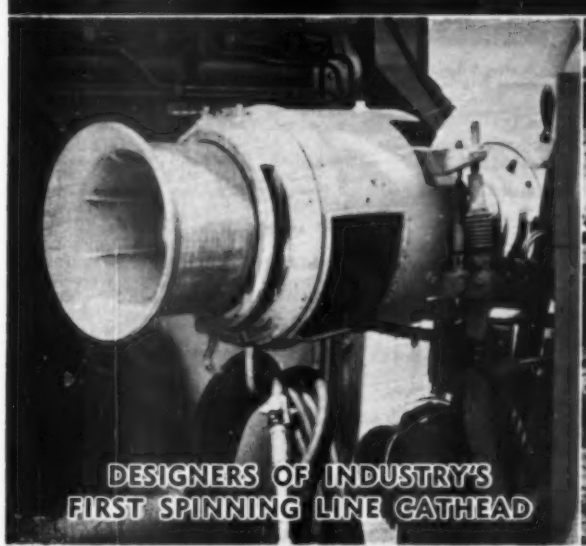
Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Avail-able to Drwwks	Rated Depth with 4½" Pipe
	8	dsl	850	Emsco A-800	1200	12,000
Coastal Drlg Co	1	dsl	3000	Emsco J-1250	1920	16,000
	2	gas	1200	Emsco J-750	1320	11,000
	4	gas	1000	Emsco GB-800	1050	12,000
H Davis & R H Thompson Co	1	dsl	300	Emsco G-300	300	6,000
Drlg & Prod Co	1	dsl	400	Crdwll	350	6,000
	2	dsl-gas-gaso	400	Crdwll 0	432	6,000
Graham & Klassen Drlg Co	2	gas	1400	Natl 75	1050	10,500
	3	gas	1500	Natl 75	1200	11,000
Green & Dreblow Drlg Co	1	dsl	600	Wlsn Giant	600	8,500
	2	dsl	600	Wlsn Giant	600	8,500
John S Hagestad Drlg Co	1	dsl	570	Emsco GB-350	400	7,000
	4	dsl	680	Ideco H-525	440	7,500
Clyde Hall Drlg Co Inc	5	gas-btne	1000	Emsco GB-800	1000	12,000
Haney & Williams Drlg Co	3	gas	1250	Natl 75	1350	10,000
	5	gas	1750	Wlsn Titan	1050	13,000
Ivy Drlg Co	1	dsl	185	Hopper IG	185	1,500
	2	btne	185	Hopper GF	185	3,000
K L Kellogg & Sons	19	dsl	1200	Natl 75	790	9,500
	25	dsl	1480	Natl 75	1480	9,500
	27	gas	2000	Natl 100	1050	13,000
	32	gas	1400	Natl 75	1050	9,500
Knight Drlg Co	1	dsl	1020	M-CSCO U-35	500	8,000
	2	dsl	1020	Natl 50-CA	720	9,500
	3	gas	1450	Beth M-58	750	11,000
L & F Drlg Co	1	gas	300	Emsco GB-250	–	5,000
	2	dsl	500	Emsco GB-250	–	5,000
Miller & York	1	dsl	275	Frnks Clipper	225	3,500
	C	dsl	550	Emsco GB-350	425	6,500
	F	dsl	735	Emsco GA-500	550	8,000
	G	dsl	275	Emsco G-36	275	5,000
	H	dsl	275	Emsco GA-250	275	5,000
	J-11	dsl	210	Hopper GTA	210	3,500
Newton Drlg Co	4-40	dsl	620	Emsco GB-250	320	6,000
Rocky Mountain Drlg Co	9	gas	1500	Natl 125	1500	20,000
	10	dsl	1850	Emsco J-1000	1850	15,000
	14	gas	1500	Emsco J-1250	1500	20,000
Santa Fe Drlg Co	3	gas	900	Emsco G-500	440	7,500
	9	gas	1050	Wlsn Titan	900	10,000
	28	gas	1200	Natl 80-B	1350	12,000
	25	gas	1200	Natl 55	900	10,000
Severns Drlg Co	1	gas	1350	Natl 100	1350	11,000
LOS ANGELES COUNTY						
Camay Drlg Co	5	gas	535	Natl 50	500	7,000
	6	gas	605	Natl 50	500	7,000
H Davis & R H Thompson Co	2	dsl	300	Emsco GA-250-T	300	6,000
Drlg & Expl Co of Del Inc	20	gas-gaso	1200	Natl 110	900	13,500
F E Gober Drlg Co	1	gas	900	Natl 50A	450	7,500
John S Hagestad Drlg Co	2	dsl	540	Ideco H30-D	340	4,500
	3	dsl	625	Emsco GB 350	400	7,000
Haney & Williams Drlg Co	1	dsl	450	Wlsn Gnt Trcr	300	5,500
	6	elec	850	Natl 75	500	10,000
Hayes & Sprague, Inc	2	dsl	1950	Natl 125	1950	16,000
K L Kellogg & Sons	28	dsl	1350	Natl 100	1100	13,000
	29	gas	1370	Natl 75	700	9,500
Rocket Drlg Co	1	gas-btne-pro	555	Emsco G-300	350	4,500
Rocky Mountain Drlg Co	6	gas	1550	Emsco J-1000	1550	15,000
	7	gas	1200	Natl 100	1110	15,000
	12	gas	1850	Natl 125	1850	20,000
	13	gas	1550	Emsco J-1250	1550	20,000
A D Rushing Inc	2	dsl	1500	Ideco T-11	1140	11,000
Santa Fe Drlg Co	29	elec	1000	Natl 3410-1/2FE	800	15,000
Simpson & Harris Drlg Co	2	gas	432	Beth	450	7,500
The Sun Drlg Co	2	gas	1400	Natl 125	2200	15,000
	3	elec	750	Natl 110	1100	15,000
	4	elec	1000	Natl 110	1100	15,000
SACRAMENTO COUNTY						
Miller & York	12	dsl	300	Hopper M	380	6,000
SAN BERNARDINO COUNTY						
Santa Rosa Drlg Co	1	prop-gas	155	–	130	2,000
SANTA BARBARA COUNTY						
The Sun Drlg Co	1	dsl	950	Natl 110	1425	15,000
SANTA PAULA COUNTY						
Haney & Williams Drlg Co	2	gas	1050	Natl 50	700	8,000
SOLANO COUNTY						
Santa Fe Drlg Co	32	dsl	450	Ideco H-40	300	6,000
VENTURA COUNTY						
Camay Drlg Co	3	gas	855	Natl 75	650	9,000
	4	gas	555	Emsco 500	500	7,500
	9	gas	1900	Natl 130	1900	16,000
Drlg & Expl Co of Del Inc	28	gas-gaso	800	Natl 50A	750	10,000
	29	gas-gaso	1500	Natl 34-10	1200	18,000
	31	gas-gaso	1500	Natl 130	1200	18,000
Graham & Klassen Drlg Co	4	gas	1400	Wlsn Titan	1050	11,000
K L Kellogg & Sons	7	gas	2240	Natl 100	1050	13,000
	31	gas	1580	Natl 125	1050	16,000
	33	gas	1750	Emsco GB-800	1050	12,000
	34	gas	2475	Natl 125	2475	16,000
	36	gas	2475	Natl 125	2475	16,000
Rocky Mountain Drlg Co	1	gas	1200	Natl 75	900	11,000
	2	gas	1200	Natl 75	900	11,000
	3	gas	1200	Natl 100	900	14,000
	4	gas-dsl	1550	"Oilwell" 96	1850	20,000
	5	gas	1850	"Oilwell" 96	1850	20,000
	8	gas	1400	Natl 125	1750	20,000
	15	gas	1200	Emsco J-750	900	11,000
A D Rushing Inc	1	dsl	525	Wlsn 42	380	6,000
	3	gas	900	Natl 50	700	7,500
	4	gas	950	Wlsn Trair Gnt	800	9,000
	5	gas	900	Natl 50	700	7,500
Santa Fe Drlg Co	26	gas	1200	Wlsn Titan	900	10,000
Simpson & Harris Drlg Co	1	gas	464	Natl 50	432	7,000
The Sun Drlg Co	5	gas	1850	Natl 110	1500	15,000
United Drlg Co	1	gas	450	Emsco EDA	450	6,000
COLORADO						
ADAMS COUNTY						
Exeter Drlg Co	2	btne	320	Emsco GA-250	250	6,000/4"
Lewis Bros Inc	3	dsl	360	Crdwll J-450	460	6,500
BACA COUNTY						
Holm Drlg Co	4	dsl	560	Wlsn Giant	300	5,500
DENVER COUNTY						
Love-Miller Drlg Co Inc	1	dsl	500	Wlsn Gnt Rdair	824	9,000
GARFIELD COUNTY						
Gardner Bros Drlg Co Inc	9	gas-btne	450	M-CSCO U-15	675	7,000
JACKSON COUNTY						
Herndon Drlg Co	8	gas	600	Natl 50-A	750	10,500
JOHNSON COUNTY						
Carpenter-Trant Drlg Co	6	dsl	450	Wlsn Giant	640	7,500
KIT CARSON COUNTY						
Exploration Drlg Co	1	gas	310	Beth S-60	500	8,000
LA PLATA COUNTY						
Arapahoe Drlg Co	6	gas-btne	1320	Natl 80 B	1320	14,000
LARIMER COUNTY						
Don M Rounds Drlg Co Inc	2	dsl	900	Crdwll 0	900	9,000
LOGAN COUNTY						
Herndon Drlg Co	3	gas	600	Natl 50	750	8,000
MESA COUNTY						
Carmack Drlg Co	5	gas	400	Natl T-32	320	6,000
Willard Pease Drlg Co	2	dsl	600	Mayhew	600	7,000
MOFFAT COUNTY						
Bueno Drlg Co	1	dsl	720	Natl T-20	300	6,500/3-1/2"
Delta Drlg Co	18	dsl	600	Natl 75	650	9,500
Nye & Snell Drlg Co	4	dsl	320	M-CSCO U-15	320	6,000
	5	dsl	600	M-CSCO U-15	600	8,000
Pioneer Drlg Co Inc	4	dsl	750	Emsco GB-500	600	9,000
MONTEZUMA COUNTY						
Foree Drlg Co	2	gas-btne	300	M-CSCO U-15	600	7,500
MORGAN COUNTY						
Lewis Bros Inc	2	btne	360	M-CSCO U-15	460	6,500
PROWERS COUNTY						
R W Rine Drlg Co	1	gas-btne	620	Brwstr N-55	600	8,500
RIO BLANCO COUNTY						
Carpenter-Trant Drlg Co	1	btne	185	Crdwl RL	185	3,000
	9	dsl	250	Franks	300	5,000
WASHINGTON COUNTY						
Brinkerhoff Drlg Co	11	dsl	275	Natl T-20	275	5,500
WELD COUNTY						
Murfin Drlg Co	5	dsl	450	Emsco 500	520	9,000
Prairie Drlg Co Inc	1	gas	–	Crdwll RL Spdr	200	11,000
FLORIDA						
DADE COUNTY						
Gulf Coast Drlg & Expl Inc	1	dsl	900	Natl 80-B	900	12,500
LEE COUNTY						
Dorris Ballew Inc	3	dsl	760	Wlsn Titan	1900	15,000
ILLINOIS						
CHRISTIAN COUNTY						
Henson Drlg Co	6	dsl	250	M-CSCO U-24	150	2,000
	7	btne	275	Crdwll S	202	4,000
Joe Simpkins	1	dsl	–	Emsco GA-160-T	500	3,500
	4	dsl	350	Spencer	350	2,500
V S & S Drlg Co	2	dsl	–	Wlsn	–	2,400
	5	gas	–	Crdwll	–	4,000
	6	gas	–	Cooper Spdr	–	3,000
CLAY COUNTY						
Calvert Drlg Inc	8	dsl	260	Ideco H-30	190	4,500
Pep Drlg Co	1	dsl	330	Beth Breeze	340	5,000
J W Rudy	1	dsl	150	Natl T-20	185	5,000
	50	dsl	250	Natl 50	214	6,000
Shulman Bros	1	dsl	330	Crdwll S-350	–	5,500
CLINTON COUNTY						
M Mazzarino	–	gas-gaso	200	Frnks 2000	200	2,500
Perrine & Perrine Drlg Contr	1	btne	–	Crdwll S	185	6,000
Shulman Bros	2	dsl	330	Crdwll L	–	3,500
CRAWFORD COUNTY						
W L Dillier	3	gas	–	Failing 2500	130	2,000
	4	gas	–	Failing 2500	130	2,000
EFFINGHAM COUNTY						
Ted Lindsay	3	dsl	220	Ideco H-30	160	4,000
FAYETTE COUNTY						
Claypool Drlg Co	2	btne	300	Natl T-12	185	4,500
FRANKLIN COUNTY						
C E Brehn	1	dsl	240	Brwstr N-45	–	7,000
E F Moran Inc	1	btne	300	Brwstr N-4	600	6,000
Pep Drlg Co	2	dsl	330	Ideco H-35	340	6,000
GALLATIN COUNTY						
Alva C Davis Expl Co	1	dsl	–	Ideco	–	–
Herndon Drlg Co	5	gas	375	Brwstr N-4	375	4,500
Lohmann-Johnson Drlg Co Inc	7	dsl	300	Crdwll S	440	4,500
V S & S Drlg Co	4	dsl	–	Beth	–	4,200
HAMILTON COUNTY						
Calvert Drlg Inc	11	dsl	260	Natl T-32	190	5,000
Herndon Drlg Co	9	gas	240	Natl T-25	390	4,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
E F Moran Inc	5	btne	145	Failing "2500"	–	2,500/3-1/2"
JASPER COUNTY						
Woody Jones Drlg Co	1	dsl	240	M-CSCO U-34	230	4,500
U & E Drlg Co	–	dsl	500	Frnks 4500	400	5,000
JEFFERSON COUNTY						
Herndon Drlg Co	7	gas	409	Natl T-32	559	5,000
Petro Drlg Co Inc	1	dsl	450	Brwstr N-4	300	6,500
KANKAKEE COUNTY						
Moran Bros Inc	14	dsl	350	Natl T-12	350	4,500
LAWRENCE COUNTY						
W L Dillier	2	gas	–	Failing 2500	130	2,000
U & E Drlg Co	–	dsl	400	Crdwll S	200	3,500
Walton Drlg Co	2	gas	–	Failing 2500	–	2,000/3-1/2"
MARION COUNTY						
Conrey Drlg Co	1	gas	140	Wlsn Super	140	2,000/3-1/2"
	2	dsl	175	Wlsn Super	174	2,500/3-1/2"
Illinois Drlg Co	2	gas-LPG	275	Natl T-12	200	4,000
Joe Simpkins	3	dsl	350	Frnks 4000	350	4,000
RICHLAND COUNTY						
Calvert Drlg Inc	16	dsl	260	Ideco H-35	190	5,000
Alva C Davis Expl Co	2	gas	–	Beth Breeze	–	–
W L Dillier	1	dsl	–	Natl T-12	212	3,000
Kendall-Davis Drlg Co Inc	1	dsl	300	Wlsn Mogul	300	4,000
Don Slape Drlg Co	1	dsl	260	"Oilwell" 64-A	230	5,000
	2	dsl	240	M-CSCO U-34	230	4,500
	3	dsl	260	"Oilwell" 64-B	230	5,500
	4	dsl	300	Brwstr N-4	245	4,500
	5	btne	360	Natl T-12	260	4,500
SALINE COUNTY						
Eakle & Holder Drlg Co	1	dsl	300	Brwstr N-4	200	5,500
SHELBY COUNTY						
Troop Drlg Co	1	gas-gaso	–	Natl T-20	200	4,500
WABASH COUNTY						
E F Moran Inc	2	btne	300	Natl T-12	300	4,500
WASHINGTON COUNTY						
Ted Lindsay	1	dsl	220	Crdwll S	160	4,500
WAYNE COUNTY						
Thompson & Wathan Drlg Co	1	btne	300	Natl T-20	185	4,500
WHITE COUNTY						
Harris Drlg Co	2	dsl	285	Natl 50	285	8,500
	3	dsl	285	Natl 50	285	8,500
Illinois Drlg Co	1	gas-LPG	325	Frnks SAL-5000	225	4,500
Ted Lindsay	2	dsl	220	Natl T-16	220	5,000
E F Moran Inc	4	btne	300	Brwstr N-3	300	3,500/3-1/2"
Joe Simpkins	2	dsl	–	Natl 20	–	5,000
INDIANA						
DAVIESS COUNTY						
Henry Gwaltney Drlg Co	3	gas	100	–	100	1,500
GIBSON COUNTY						
Eakle & Holder Drlg Co	2	dsl	400	Emsco G-300	400	5,500
Henry Gwaltney Drlg Co	1	dsl	200	Natl T-12	165	3,000
Harris Drlg Co	1	btne	195	Crdwll S	172	4,000
Houchins Drlg Co	1	dsl	300	Natl T-20	300	4,500
Lohmann-Johnson Drlg Co Inc	6	btne	300	Crdwll S	440	4,500
E F Moran Inc	3	btne	300	Crdwll S	300	4,000
The Noah Petroleum Co	1	dsl	300	Brwstr N-4	300	5,500
Walton Drlg Co	1	gas	–	Failing 2500	–	2,000/3-1/2"
KNOX COUNTY						
Henry Gwaltney Drlg Co	2	gas-prop	200	Crdwll	165	3,000
POSEY COUNTY						
Calvert Drlg Inc	12	dsl	260	Ideco H-30	260	4,500
General Geophysical Co	27	dsl	–	–	400	4,500
Kendall-Davis Drlg Co Inc	2	dsl	300	Crdwll S	300	4,000
SULLIVAN COUNTY						
T & H Corp	1	dsl	225	Crdwll L	225	3,500
IOWA						
DALLAS COUNTY						
Kirby Oil Ind	–	dsl	380	M-CSCO U-34	275	4,500
	–	gas-gaso	400	Mayhew 3000	145	3,000
	–	dsl	400	Brwstr N-4	400	4,500
KANSAS						
BARBER COUNTY						
Graham-Michaelis Drlg Co	6	dsl	275	Beth Breeze	175	4,000
Patton Drlg Co Inc	2	dsl	–	Natl 50	350	5,500
BARTON COUNTY						
Thos H Allan	1	btne	175	Crdwll K	250	4,000
Bennett & Roberts Drlg Inc	3	dsl	250	Emsco 250	250	5,000
Isern Drlg Co	1	dsl	450	M-CSCO U-15	450	7,000
Murfin Drlg Co	3	dsl	260	Natl T-20	260	5,000
Reserve Drlg Co Inc (Kans)	3	dsl	320	Natl T-32	320	5,500
Shelley-Miller Drlg Co	1	dsl	329	Wlsn-Gnt	300	4,860
Shields Drlg Co Inc	3	dsl	300	Wlsn Giant	400	6,000
CHANUTE COUNTY						
Smiley & Little Drlg Co	4	gas	100	Wlsn	100	2,600
CLARK COUNTY						
Graham-Michaelis Drlg Co	10	dsl	600	M-CSCO U-15	600	9,000
COMANCHE COUNTY						
Patton Drlg Co Inc	1	gas	–	Natl 50	450	6,500
COWLEY COUNTY						
Earl F Wakefield	1	dsl	440	Wlsn Mogul Rdair	440	5,000
CRAWFORD COUNTY						
Walters Drlg Co Inc	3	gas	130	Mayhew	130	1,000
EDWARDS COUNTY						
Herndon Drlg Co	6	gas	409	Natl T-32	559	6,000
L C Smitherman Drlg Co	3	dsl	265	Brwster N-4	265	5,500
ELLIS COUNTY						
A L Jackson Drlg Co	1	dsl	285	M-CSCO U-15	285	6,000
Murfin Drlg Co	2	dsl	200	Natl T-20	260	5,000
Quaker Drlg Co Inc	2	dsl	185	M-CSCO U	350	4,500
Transit Corp	3	dsl	280	Emsco	–	4,500
ELLSWORTH COUNTY						
Buick Drlg Inc	2	dsl	300	Wilson	–	4,500
FINNEY COUNTY						
Helmerich & Payne Inc	26	gas	500	Emsco GB-500	700	9,000
Tommy Ward Drlg Co	2	gas	300	Brwstr N-45	600	7,500
GRAHAM COUNTY						
Barnett Drlg Inc	6	dsl	265	Natl T-25	265	5,000
Empire Drlg Co (Kans)	1	dsl	300	Natl T-32	300	5,000
Herndon Drlg Co	10	gas	409	"Oilwell" 64-A	559	4,500
K & E Drlg Inc	2	dsl	285	Natl T-20	285	5,000
Murfin Drlg Co	4	dsl	260	Wlsn Rdair	450	7,000
GRANT COUNTY						
Helmerich & Payne Inc	7	gas	500	Emsco GB-500-82	700	9,000
Moran Bros Inc	16	gas	650	M-CSCO U-15	600	7,500
R W Rine Drlg Co	5	gas-btne	520	Brwstr N-55	550	8,500
HAMILTON COUNTY						
Calvert Drlg Inc	15	dsl	260	Ideco H-35	260	5,000
Graham-Michaelis Drlg Co	3	dsl	300	Crdwll S	175	5,000
HARPER COUNTY						
Lohmann-Johnson Drlg Co Inc	3	btne	300	Natl 50	450	5,500
Walters Drlg Co	1	gas-btne	–	Natl 50	500	5,500
HASKELL COUNTY						
D & M Drlg Co Inc	3	dsl	600	M-CSCO U-15	600	8,000
HODGEMAN COUNTY						
Graham-Michaelis Drlg Co	8	dsl	400	Crdwll D	400	5,000
KINGMAN COUNTY						
Beardmore Drlg Co	1	dsl	300	Natl 50	450	6,000
Pickrell Drlg Co	1	dsl	450	M-CSCO U-15	450	6,500
Powell Drlg Co	1	dsl	–	Emsco GB-350	350	6,500
Rupp-Ferguson Oil Co	1	dsl	350	Ideco H-35	350	5,000
KIOWA COUNTY						
Pickrell Drlg Co	10	dsl	270	Ideco	300	6,500
LIBERAL COUNTY						
General Drlg Co	1	–	–	M-CSCO U-15	–	9,000
	5	–	–	M-CSCO U-15	–	9,000
MARION COUNTY						
Mallard Drlg Co	1	dsl	285	Emsco G-300	285	4,000
McPHERSON COUNTY						
Donald T Ingling	4	dsl	225	Brwstr N-4	225	5,500
MEADE COUNTY						
Bennett & Roberts Drlg Co	1	dsl	500	Emsco 500	500	8,000
	2	dsl	250	Emsco 250	250	6,000/3-1/2"
D & M Drlg Co Inc	1	gas-btne	550	Natl 50	550	8,000
Lynn Drlg Co	1	gas-btne	300	Natl 50	600	8,000
PAWNEE COUNTY						
K & E Drlg Inc	1	dsl	285	"Oilwell" T-52	285	6,000
Mallonee Drlg Co Inc	1	btne	240	Beth Breeze	240	5,000
RICE COUNTY						
Quaker Drlg Co Inc	1	dsl	185	Wilson	185	3,600
ROOKS COUNTY						
Transit Corp	2	dsl	280	Emsco	–	4,500
	4	dsl	280	Emsco	212	4,500
RUSSELL COUNTY						
Mast Drlg Inc	2	dsl	185	Natl T-32	250	5,500
Shields Drlg Co Inc	2	dsl	300	Beth C-50	300	8,000
SALINE COUNTY						
Veeder Supply & Dev Co	E	dsl	270	Frnks 658	270	3,500
SEWARD COUNTY						
Tommy Ward Drlg Co	3	gas	350	Brwstr N-35	650	5,000
STAFFORD COUNTY						
Barnett Drlg Inc	5	dsl	265	Natl T-25	265	5,000
Rex & Morris Drlg Co	1	dsl	260	Natl T-25	260	4,000
STEVENS COUNTY						
Earl F Wakefield	2	dsl	640	Wlsn Gnt Rdair	640	8,500
SUMNER COUNTY						
Beardmore Drlg Co	2	dsl	300	Emsco 300	320	4,000
Herndon Drlg Co	1	gas	409	"Oilwell" 64-B	559	6,000
TREGO COUNTY						
Veeder Supply & Dev Co	D	dsl	280	Natl T-25	300	4,500
KENTUCKY						
DAVIESS COUNTY						
V-T Drlg Co	1	dsl	220	Crdwll H	160	4,000
HENDERSON COUNTY						
Big Seven Drlg Co	1	dsl	300	Emsco GB	300	4,500
Temple Drlg Co Inc	2	dsl	300	Crdwll S	440	4,500
MARTIN COUNTY						
Moran Bros Inc	1	gas	1000	"Oilwell" 760	1200	14,000
WEBSTER COUNTY						
Eakle & Holder Drlg Co	3	dsl	300	Ideco H-30	300	5,500

LOUISIANA

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ACADIA PARISH						
Pernie Bailey	1	gas	650	Brwstr N-75	–	11,000
Comet Drlg Co	2	dsl	1000	Natl 75	750	10,000
Delta Drlg Co	38	stm	530	Natl 239-S	1135	12,000
Dillard-Waltermire Inc	4	stm	1200	Natl 34-10FE	1500	16,000
Drlg & Expl Co of Del Inc	36	stm	1400	Natl 34-8	–	15,000
Douglas Drlg Co	2	gas-btne	600	Emsco GA-250T	250	5,500
A W Eggleston Inc	2	gas-btne	700	Ideco PR-800	700	10,500
Mac Drlg Co	3	stm	600	Natl 23-9-FE	1000	20,000
The Power Rig Drlg Co Inc	10	dsl	2250	Emsco A-1500	2000	25,000
Prince Marine Drlg & Exp Co	3	gas	1150	Emsco A550	950	10,500
Sunnyland Contr Co Inc	8	gas-gaso	–	Crdwll D	312	8,000
ALLEN PARISH						
Owen Drlg Co	6	gas	600	Natl 75	600	12,000
Penrod Drlg Co	23	dsl	795	Brwstr N-7	700	10,000
ASCENSION PARISH						
Win Hawkins Drlg Co	4	stm	–	Natl 3410FE	–	15,000
The Power Rig Drlg Co Inc	4	gas-btne	700	M-CSCO U-15	–	10,000
ASSUMPTION PARISH						
Delta Drlg Co	32	stm	1200	Ideco Big Gnt	1690	15,000
Gracey-Heffums Corp Bge	2	stm	1200	Natl 23-9FE	1200	15,000
BEAUREGARD PARISH						
The Power Rig Drlg Co Inc	3	gas-btne	1000	Emsco A-800	–	13,000
W P Taylor Drlg Co	1	gas	–	Emsco	1000	13,000
Wheless Drlg Co	3	gas-btne	575	Emsco GB-350	450	7,500
Fred Wilson Drlg Co	10	gas	1050	Natl 55	800	10,500
	11	gas	1050	Natl 55	800	10,500
BIENVILLE PARISH						
J B Fletcher Drlg Co	1	gas-btne	–	M-CSCO U-15	600	7,500
BOSSIER PARISH						
Crow Drlg & Prod Co	5	dsl	825	Brwstr N-7	825	9,000
CADDO PARISH						
Burnham & Robinson Drlg Co	1	dsl	350	Brwstr N-5	350	7,000
Crow Drlg & Prod Co	17	dsl	650	Brwstr CR-48T	650	7,500
Gary Drlg Co	1	btne	145	Hercules WXLC-3	63	1,600
	2	btne	145	6-MO-893	118	2,500
	3	btne	170	Brwstr N-5	165	10,000
F E Hargraves & Sons Drlg	2	btne	185	Brwstr W-50	185	2,800/3-1/2"
Johnson Drlg & Serv Co	1	dsl	340	Beth Breeze	200	4,500
Kendrick Bros	1	btne	185	Brwstr N-4	185	5,000
Montgomery Drlg Co	1	gas-btne	700	Emsco GA-500	600	9,500
J C Trahan Drlg Contr Inc	7	dsl	2400	M-CSCO U-20	2400	20,000
CALCASIEU PARISH						
Comet Drlg Co	1	stm	1200	Ideco Big Gnt	–	16,000
Delta Drlg Co	20	gas-btne	1520	Emsco J-1250	1250	15,000
Mac Drlg Co	11	stm	800	Natl 23-9F-ED	1000	20,000
Steen Drlg Co	1	stm	750	Emsco ECB	–	17,000
Sunnyland Contr Co Inc	9	dsl	–	Crdwll D	450	8,000
CALDWELL PARISH						
Barnwell Drlg Co Inc	45	dsl	800	Brwstr N-45M	650	8,000
CAMERON PARISH						
Pernie Bailey	2	gas	800	M-CSCO U-40	–	11,000
Brewster-Bartle Drlg Co Inc	14	dsl	–	Natl 125	–	16,000
Circle Drlg Co Inc	5	gas-btne	1550	Brwstr N-12	1440	15,000
Delta Drlg Co	35	gas-btne	1200	Emsco J-1100	1200	15,000
Eilers Drlg Co	3	gas-btne	580	M-CSCO U-15	550	9,500
Win Hawkins Drlg Co	1	stm	–	Alco BW 14	–	15,000
Penrod Drlg Co Bge	40	dsl	1850	Brwstr N-12-A	1725	18,000
Symons Drlg Co U-15		gas	500	M-CSCO U-15	650	10,000
C B Webster Drlg Co	3	gas	1250	Emsco J-1250	1300	15,000
Wheless Drlg Co Bge	12	gas-btne	1085	Natl 80	1300	12,000
CATAHOULA PARISH						
Scooter's Drlg Serv	2	dsl	300	Brwstr N-4	300	4,500
	3	dsl	600	Brwstr N-55	600	6,000
	4	dsl	300	Wlsn Giant	300	4,500
Thrasher Drlg Co Inc	1	gas-btne	350	M-CSCO U-15	600	8,500
CLAIBORNE PARISH						
Arrow Drlg Co	22	dsl	1200	Emsco 1000	–	14,000
Butler-Johnson Inc	1	gas-btne	650	Brwstr N-75	1005	10,000
Drlg & Expl Co of Del Inc	32	stm	1400	Emsco ECA	–	15,000
Maritzky & Bibby	1	gas	330	Brwstr	185	5,000
	2	gas	330	Crdwll	145	3,000
CM Roberson Drlg Co	1	gas-btne	400	Brwstr N-45	400	7,300
Wheless Drlg Co	1	gas-btne	510	Brwstr N-45	450	7,500
Woolf & Magee Inc	5	gas-btne	800	Beth MC-450	800	11,000
CONCORDIA PARISH						
Dorris Ballew Inc	6	dsl	380	M-CSCO U-15	600	7,500
Petersen Petroleum Corp	5	gas	320	Crdwll S	350	6,000
DE SOTO PARISH						
Hilburn Industries Inc	2	gas	550	Wlsn	550	10,000
EAST CARROLL PARISH						
Butler-Johnson Inc	2	gas-btne	450	Brwstr N-55	450	8,000

KELCO PIONEER IN SAFETY DRILLING EQUIPMENT



SPINNING LINE CATHEADS • BREAKOUT CATHEADS
AIR OPERATED POWER SLIPS • TUBING TONGS

KELCO BEN F. KELLEY CO., Inc.
TULSA, OKLAHOMA

SALES AND SERVICE REPRESENTATIVES IN MAJOR DOMESTIC OIL CENTERS FOR EXPORT, CONTACT IDECO—ONE OF THE DRESSER INDUSTRIES OR YOUR FAVORITE SUPPLY COMPANY

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
EVANGELINE PARISH						
A W Eggleston Inc	3	dsl	1500	Ideco PR-1050	1500	14,000
Harris Drlg Co Inc	5	gas	175	Crdwll K	175	11,000/2"
Penrod Drlg Co	6	dsl	2000	Natl 110	1350	16,500
Fred Wilson Drlg Co	12	gas	1300	Natl 110	1200	15,000
FRANKLIN PARISH						
Crow Drlg & Prod Co	19	dsl	325	Brwstr C-5	325	7000/3-1/2"
IBERIA PARISH						
Eilers Drlg Co	2	gas-btne	375	M-CSCO U-10	400	8,000
Prince Marine Drlg & Exp Co	2	dsl	1850	"Oilwell" 96	1500	16,000
Wheless Drlg Co	4	stm	1000	Emsco UBLS-54	1000	15,000
IBERVILLE PARISH						
Circle Drlg Co Inc	3	gas-elec	1500	Ideco Big Gnt	2100	15,000
Delta Drlg Co	11	stm	1000	Emsco UBLS-54	1690	15,000
M M Lindsey Drlg Co	1	gas	380	Brwstr N-55	–	7,500
JEFFERSON PARISH						
Two R Drlg Co Inc	Bge 1	dsl	4000	Beth B-3661	3000	25,000
JEFFERSON DAVIS PARISH						
Columbia Drlg Co	2	gas	1125	Natl 75	675	11,500
Delta Drlg Co	14	stm	900	Ideco Big Gnt	1690	15,000
	21	gas-btne	800	Natl 75	650	9,500
Rowan Drlg Co Inc	4	gas-btne	900	Natl 75	1149	11,000
Steen Drlg Co	2	stm	600	Emsco ECA	–	16,000
C B Webster Drlg Co	7	stm	1600	Emsco ECA-10½	1200	15,000
Fred Wilson Drlg Co	9	gas	1200	Natl 80-3	800	12,500
LAFAYETTE PARISH						
Dillard-Waltermire Inc	8	stm	1200	Natl 34-10FE	1500	16,000
Owen Drlg Co	3	gas	900	Ideco M-1000	–	12,500
	7	stm	1000	Emsco	–	16,000
Prince Marine Drlg & Exp Co	4	gas	1600	Emsco J-1100	1400	15,000
LA FOURCHE PARISH						
An-Son Drlg Co	5	gas	1350	Natl 80-B	1200	12,500
Brewster-Bartle Drlg Co Inc	6	dsl	–	"Oilwell" 96	1500	–
Delta Drlg Co	37	dsl	900	Beth MC-950	1400	15,000
Kelly Drlg Co Inc	1	stm	1200	Ideco Jr Gnt	1500	15,000
	3	pwr	1850	"Oilwell" 96	1500	18,000
Marine Drlg Inc	5	stm	1800	Emsco UBLS4	1000	15,000
Norton Drlg Co	4	dsl	1600	Emsco J-1250	1600	17,000
Penrod Drlg Co	17	gas-btne	1900	Brwstr N-12-A	1650	18,000
	Bge 45	dsl	1850	Emsco J-1400	1575	20,000
	Bge 51	dsl	2000	Emsco EDES	1200	20,000
Reading & Bates Inc	1	gas-btne	900	Natl 100	1200	12,500
Rowan Drlg Co Inc	Bge 1	dsl-elec	1600	Emsco ECA	2475	18,000
C B Webster Drlg Co	1	dsl	1650	"Oilwell" 96	1800	18,000
Wheless Drlg Co	Bge 6	gas-btne	1000	Wlsn Titan	1200	12,000
	Bge 11	gas-btne	1085	Emsco J-1250	1400	13,500
Fred Wilson Drlg Co	7	gas	1200	Natl 80-B	800	12,500
LINCOLN PARISH						
Arrow Drlg Co	5	gas	1250	Emsco	–	14,000
H & S Drlg Co	1	gas-btne	1000	Wlsn Titan	1000	12,000
Johnson Drlg & Serv Co	2	dsl	500	Beth Twister	300	6,500
Pyburn Drlg Co	2	gas	250	Wilson	800	9,000
Wheless Drlg Co	2	gas-btne	575	Wlsn Atlas	450	8,500
MADISON PARISH						
Jett Drlg Co Inc	105	dsl	600	Natl T-32	500	8,000
MARSH ISLAND						
Circle Drlg Co Inc	Bge 6	dsl-elec	2300	Ideco E2500	2750	20,000
OUACHITA PARISH						
H & S Drlg Co	2	gas-btne	1000	Brwstr N-95	1000	14,000
Wheless Drlg Co	Bge 10	gas-btne	770	Brwstr N-7	800	9,500
	13	gas-btne	640	Emsco J-750	850	10,500
PLAQUEMINES PARISH						
Bateman Drlg Co	Bge 5	dsl-elec	900	Emsco EDA 54	1000	15,000
Clinch Drlg Co	Bge 1	dsl	–	Emsco GA-350	426	8,500
Continental Shelf Drlg Corp	Belle Claire	dsl	1700	Beth 1013	1950	18,000
	West Cote # 10	dsl	1600	Ideco 1050	1320	14,000
Marine Drlg Inc	Dac	dsl	1500	Beth Tornado	1500	15,000
Penrod Drlg Co	Bge 47	dsl-elec	2650	Emsco EDA	1250	20,000
Prince Marine Drlg & Exp Co	1	dsl	1500	"Oilwell" 96	1500	15,000
Producers Drlg Co Inc	1	dsl	2000	M-CSCO U-1220	2200	20,000/5"
	2	dsl	2150	M-CSCO U-914B	1800	18,000/5"
Rowan Drlg Co Inc	Bge 18	stm	1900	Emsco ED	750	18,000
	Bge 20	dsl	1120	Natl 75	1300	12,000
POINT COUPEE PARISH						
Crown Rigs Inc	6	gas	900	Beth MC-450	600	10,000
RICHLAND PARISH						
F E Hargraves & Sons Drlg	4	dsl	275	Brwstr N-A	300	6000/3-1/2"
Montgomery Drlg Co	3	gas-btne	225	Crdwll S	200	5,000
ST. CHARLES PARISH						
Bateman Drlg Co	Bge 6	dsl-elec	900	Emsco UBLS 54-10	1600	16,000
Circle Drlg Co Inc	7	gas-btne	1500	Ideco 7-11	1200	15,000
	8	gas-btne	1200	M-CSCO U-20	1500	13,000
Penrod Drlg Co	Bge 41	dsl	1000	Emsco J-1100	1100	14,000
ST JOHN THE BAPTIST PARISH						
The Power Rig Drlg Co	8	gas-btne	1500	Ideco 7-11	–	15,000
ST. LANDRY PARISH						
Circle Drlg Co Inc	4	gas-btne	800	Brwstr N-75	960	11,000
Harris Drlg Co Inc	3	gas	230	Crdwll RL	230	13,000/2"
ST. MARTIN PARISH						
Brewster-Bartle Drlg Co Inc	10	dsl	–	"Oilwell" 76	–	11,000
Delta Drlg Co	5	gas-btne	900	Natl 100	800	12,000
Rowan Drlg Co Inc	Bge 21	dsl-elec	1000	Emsco ECA	1920	12,000
ST. MARY PARISH						
An-Son Drlg Co	5	gas	1350	Natl 80-B	1200	12,500
An-Son Offshore Drlg Co	Bge 1	dsl	1150	Natl 75	900	11,000
Brewster-Bartle Drlg Co Inc	9	dsl	–	"Oilwell" 96	1500	16,000
Crown Rigs Inc	Bge 1	dsl	1700	Beth 1013	1425	15,000
M M Lindsey Drlg Co	2	gas	290	Natl T-32	–	6,000
Mac Drlg Co	10	gas-btne	1000	Natl 130	1300	20,000
Norton Drlg Co	Bge 3	stm	1200	Natl 34-62	1500	17,000
Owen Drlg Co	1	stm	540	Ideco Big Gnt	–	15,000
Penrod Drlg Co	16	gas-btne	1900	Emsco J-1400	1650	18,000
	Bge 50	dsl	2625	Emsco EDES	1250	20,000
	Bge 52	dsl	2000	Emsco EDES	1200	20,000
Rimrock Tidelands Inc	15	dsl	2000	Brwstr N-12-A	2000	20,000
	Bge 18	dsl	1000	Emsco GC-500	1500	10,000
Rowan Drlg Co Inc	Bge 6	dsl-elec	1200	Emsco ED	2800	18,000
	Bge 13	dsl-elec	1700	Emsco FCA	2700	18,000
C B Webster Drlg Co	5	stm	1350	Emsco ECA 10½	1200	15,000
	6	dsl	2000	Emsco J 1400	2400	17,000
	Bge 9	dsl	1850	Emsco J-1400	2200	17,000
Wheless Drlg Co	Bge 14	dsl	1700	Emsco J-1400	1470	18,000
Fred Wilson Drlg Co	8	gas	1600	Natl 110	1200	15,000
TENSAS PARISH						
Jett Drlg Co Inc	107	dsl	600	Brwstr N-45	400	7,000
	112	dsl	1200	Brwstr 55	800	9,000
Penrod Drlg Co	2	gas-btne	570	Brwstr N-45	550	6,500
Woolf & Magee Inc	7	gas-btne	800	Beth MC-450	800	11,000
TERREBONNE PARISH						
Brewster-Bartle Drlg Co Inc	5	dsl	–	"Oilwell" 96	1500	16,000
	7	dsl	–	"Oilwell" 96	1500	16,000
	8	dsl	–	"Oilwell" 96	1500	16,000
	11	dsl	–	"Oilwell" 96	1500	16,000
	12	dsl	–	"Oilwell" 96	1500	16,000
Crown Rigs Inc	Bge 2	dsl	2490	Beth 1013	2000	18,000
Delta Drlg Co	17	gas-btne	1020	Emsco J-1100	1300	15,000
	25	gas-btne	1520	Emsco J-1250	1250	15,000
	31	gas-btne	1020	Emsco J-1000	1260	13,000
Gracey-Hellums Corp	Bge 3	dsl	1775	M-CSCO U-1220	1800	20,000
	Bge 4	dsl	1775	Emsco A-1500	1900	20,000
Kelly Drlg Co Inc	2	pwr	1200	"Oilwell" 96	1500	18,000
Marine Drlg Inc	4	dsl-elec	3000	Emsco EDA	1600	20,000
Norton Drlg Co	Bge 5	dsl	1600	"Oilwell" 96	1600	17,000
	Bge 6	dsl	1400	Emsco J-1250	1200	17,000
Penrod Drlg Co	33	dsl	1765	Brwstr N-12-A	1725	18,000
	Bge 42	dsl	2000	Brwstr N-12-A	1100	18,000
	Bge 46	dsl-elec	2500	Emsco ECB	1250	20,000
Rowan Drlg Co Inc	Bge 26	dsl	1125	Natl 100	1545	14,000
Wheless Drlg Co	Bge 8	dsl	1700	Natl 130	1900	18,000
	Bge 9	dsl	1450	Natl 130	1470	18,000
	Bge 15	dsl	1975	Natl 130	1900	18,000
UNION PARISH						
Monroe Drlg Co Inc	1	stm	260	Natl U-2	–	12,000
VERMILION PARISH						
Brewster-Bartle Drlg Co Inc	2	dsl	–	"Oilwell" 96	1500	16,000
Delta Drlg Co	19	stm	1200	Natl 34-10-FE	1690	15,000
Dillard-Waltermire Inc	6	stm	1200	Natl 34-10-FE	1500	16,000
A W Eggleston Inc	1	gas-btne	600	Natl 60A	600	9,500
Grey Wolf Drlg Co	3	stm	1050	Alco BW 12	–	13,500
Win Hawkins Drlg Co	5	dsl	200	Ideco PR1050	900	15,000
Owen Drlg Co	4	stm	1000	Emsco UBLS-54	–	14,000
	9	stm	740	Ideco Big Gnt	540	16,000
Reading & Bates Inc	4	dsl	1680	Natl 110	1800	15,000
Rowan Drlg Co Inc	Bge 3	dsl-elec	2150	Emsco EDA	3455	20,000
	Bge 14	dsl-elec	1600	Emsco ECA	2325	18,000
C B Webster Drlg Co	4	stm	1200	Natl FE-34-10	1200	15,000
	8	stm	1600	Natl FE-23-10½	1200	15,000
WEBSTER PARISH						
Penrod Drlg Co	11	gas	1100	Natl 100	1400	13,500
	26	gas-btne	1400	M-CSCO U-20	1400	14,000
Woolf & Magee Inc	1	stm	1000	Natl 34-10-FE	1200	15,000
MICHIGAN						
ALLEGAN COUNTY						
Union Rotary Drls (Can) Ltd	3	gas-LPG	375	Natl 40	180	4,000
OCEANA COUNTY						
Bernhardt Drlg Co	1	dsl	300	Failing 2500	300	3500/2-7/8"
MISSISSIPPI						
Marshall R Young Drlg Co	6	stm	1688	Natl 34	1480	16,000
	7	stm	1688	Natl 34	1480	16,000
ADAMS COUNTY						
Fortenbery Drlg Co Inc	1	dsl	500	Ideco H-40	300	7,500
	4	dsl	500	Ideco H-30	275	7,000
	5	dsl	500	Wlsn Giant	350	9,000
Woolf & Magee Inc	10	gas-btne	275	Beth Breeze	275	10,000/2-7/8"
AMITE COUNTY						
Darris Ballew Inc	4	dsl	760	Wlsn Titan	1900	15,000
CLARKE COUNTY						
A W Williams Drlg Co Inc	1	dsl	186	Joy 300	220	4,500/4"
COVINGTON COUNTY						
Gulf Coast Drlg & Expl Inc	6	dsl	1000	Ideco Super 7-11	1800	16,000
FORREST COUNTY						
Win Hawkins Drlg Co	2	gas-btne	300	M-CSCO U-15	485	9,000
HINDS COUNTY						
Drlg & Expl Co of Del Inc	41	gas-gaso	1500	Emsco J-1100	1050	15,000
HUMPHREYS COUNTY						
Woolf & Magee Inc	12	gas-btne	275	Beth S-45	275	10,000/2-7/8"

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
JASPER COUNTY						
Jett Drlg Co Inc	108	dsl	1250	Brwstr N-75	1000	12,000
JEFFERSON DAVIS COUNTY						
Big Chief Drlg Co	34	dsl-elec	2560	Emsco EDA-460	1600	18,000
JONES COUNTY						
Zach Brooks Drlg Co	4	gas	1350	Brwstr N-75	1350	12,000
	7	dsl	1350	Emsco J-1100	1350	14,000
Gulf Coast Drlg & Expl Inc	3	dsl	900	Natl 80-B	900	12,500
Travis Ward Drlg Co	3	gas-LPG	2000	Wlsn Spr Titan	1400	16,000
Woolf & Magee Inc	8	gas-btne	1300	Beth Tornado	1300	15,000
Marshall R Young Drlg Co	5	–	1350	Wlsn Titan	1122	14,000
	11	–	1350	Wlsn Titan	1122	14,000
LAMAR COUNTY						
Gulf Coast Drlg & Expl Inc	4	dsl	800	Natl T-32	800	6,500
LINCOLN COUNTY						
Dorris Ballew Inc	1	dsl	760	Wlsn Titan	1300	12,500
Drlg & Expl Co of Del Inc	37	gas-gaso	1200	Emsco GB-800	900	12,000
Hawkins-Wilkins Prod Co	1	stm	–	Natl 34-10-FE	–	15,000
Reading & Bates Inc	2	gas-btne	900	Natl 75	1020	11,000
	3	gas-btne	900	Natl 75	1020	11,000
Rimrock Tidelands Inc	12	gas-btne	1000	Natl 75	1215	12,000
Marshall R Young Drlg Co	1	–	900	Natl 75	648	11,500
	3	–	900	Natl 75	830	11,500
	12	–	740	Natl 50-A	558	10,000
PEARL RIVER COUNTY						
Crow Drlg & Prod Co	16	dsl	1100	Brwstr N-10	1100	12,000
Sunnyland Contr Co Inc	7	dsl	–	Ideco H-40	450	8,000
	12	dsl	1120	Ideco H-525 SC	1000	10,000
A W Williams Drlg Co Inc	4	dsl	700	M-CSCO U-15	700	11,000/4"
PIKE COUNTY						
Dorris Ballew Inc	2	dsl	760	Wlsn Titan	1300	12,500
Barnwell Drlg Co Inc	9	gas	1800	Brwstr N-95	1800	20,000
Rimrock Tidelands Inc	8	dsl	900	Brwstr N-75	900	11,000
RANKIN COUNTY						
Rimrock Tidelands Inc	19	dsl	1410	Beth MC-950	1200	18,000
Marshall R Young Drlg Co	8	–	1350	Wlsn Titan	1122	14,000
SCOTT COUNTY						
Rimrock Tidelands Inc	20	dsl	675	Brwstr N-55	900	10,000
A W Williams Drlg Co Inc	3	dsl	300	Brwstr N-4	300	8,500/4"
SIMPSON COUNTY						
Arrow Drlg Co	18	gas	1260	Emsco 1250	–	14,000
Dorris Ballew Inc	8	dsl	1380	Natl 125	1725	16,000
Gulf Coast Drlg & Expl Inc	2	dsl	1200	Natl 110	1200	14,000
Hawkins-Wilkins Prod Co	2	dsl	–	Ideco PR-1050	900	15,000
Jett Drlg Co Inc	106	dsl	1600	Brwstr N-95	1400	13,000
	110	dsl	1400	Brwstr N-95	1400	14,000
Rowan Drlg Co Inc	30	dsl	1545	Emsco A-1500	1545	20,000
SMITH COUNTY						
Zach Brooks Drlg Co	9	gas-btne	1350	Brwstr N-95	1350	14,000
	8	gas	2600	Brwstr N-12	2600	18,000
Jett Drlg Co Inc	111	dsl	2000	Natl 110	1500	15,000
Mr Kemp		dsl	2000	Gardnr-Denver	2100	30,000
Rimrock Tidelands Inc	10	gas-btne	1400	Natl 110	1900	15,000
	11	gas-btne	1325	M-CSCO U-20	1900	20,000
	14	dsl	2000	Emsco A-1500	2000	20,000
Rowan Drlg Co Inc	8	gas-btne	1920	Natl 125	1920	18,000
WALTHALL COUNTY						
Gulf Coast Drlg & Expl Inc	5	–	–	–	–	–
WAYNE COUNTY						
Drlg & Expl Co of Del Inc	39	gas-gaso	1200	Emsco J-1100	1050	15,000
Rimrock Tidelands Inc	21	dsl	500	Emsco GB-500	600	10,000
WILKINSON COUNTY						
Woolf & Magee Inc	11	gas-btne	275	Beth S-45	275	10,000 2-7/8"
MONTANA						
CARBON COUNTY						
J D Sprecher	2	dsl	900	Emsco J-750	900	10,500
DAWSON COUNTY						
Helmerich & Payne Inc	29	gas	950	Natl 75CA	1100	11,000
FALLON COUNTY						
Zach Brooks Drlg Co	6	dsl	1300	Brwstr N-75	1300	12,500
Roden & McRae Drlg Corp	3	dsl	900	Emsco GB-800	900	12,500
LEWIS & CLARK COUNTY						
Hose-Austin Drlg Corp	3	gas	450	M-CSCO U-15	550	7,000
McCONE COUNTY						
Great Northern Drlg Co Inc	3	dsl	600	M-CSCO U-15	600	9,000
MUSSELSHELL COUNTY						
Hose-Austin Drlg Corp	4	gas	500	Emsco GB-350	588	7,500
Willard Pease Drlg Co	1	dsl	340	Stratmaster 90	320	5500/3-1/2"
POWDER RIVER COUNTY						
Earl F Wakefield	5	gas-btne	550	Wlsn Gnt	550	6,500
ROSEBUD COUNTY						
Brinkerhoff Drlg Co	2	dsl	350	Natl 50-A	600	7,000
Great Northern Drlg Co Inc	1	dsl	300	Crdwll	300	6,000
Hewit-Gulick Drlg Co	4	dsl	370	Natl T-32	356	6,000
Hose-Austin Drlg Corp	1	dsl	350	Emsco GB-250T	450	6,000
Pioneer Drlg Co Inc	6	dsl	850	Emsco GB-800	1000	12,500
SHERIDAN COUNTY						
Helmerich & Payne Inc	33	gas	850	"Oilwell" 76	1100	11,000
TETON COUNTY						
Great Northern Drlg Co Inc	2	dsl	300	Crdwll	300	6,000
WIBAUX COUNTY						
Hewit-Gulick Drlg Co	2	dsl	970	Natl 80	900	12,000
NEBRASKA						
BANNER COUNTY						
Brinkerhoff Drlg Co	23	dsl	375	Natl T-20	275	5,500
Exeter Drlg Co	4	dsl	400	Natl T-32	300	6,000
Herndon Drlg Co	2	gas	600	Natl 50-A	750	10,500
KIMBALL COUNTY						
Ashby Drlg Co Ltd	1	dsl	300	Natl T-20	300	8,000/3-1/2"
	2	dsl	300	Natl T-20	300	8,000/3-1/2"
Brinkerhoff Drlg Co	10	dsl	400	Emsco GC 350T	400	6,000
Exeter Drlg Co	1	dsl	325	Emsco GA-350	425	7,000
Lewis Bros Inc	1	dsl	376	Crdwll J-450	476	7,500
McDaniel Drlg Co	1	dsl	350	Ideco H-40	350	6,000
Don M Rounds Drlg Co Inc	1	dsl	530	Natl 50	530	6,500
RICHARDSON COUNTY						
Nemaha Oil Co	1	dsl	370	Franks SAL 3000	370	4,500/3-1/2"
NEVADA						
CHURCHILL COUNTY						
Barry Well Drlg Co	2	dsl	200	–	–	2,500/3-1/2"
NEW MEXICO						
BLOOMFIELD COUNTY						
Brannon & Murray Drlg Co	5	dsl	300	Brwstr N-4	300	5,000
CHAVES COUNTY						
Delta Drlg Co	9	gas-btne	936	Natl 100	800	12,000
Great Western Drlg Co	4	gas	450	M-CSCO U-40	1100	10,000
Moran Oil Prod & Drlg Corp	1	gas	–	M-CSCO U-15	800	8,500
CLARK COUNTY						
Miller & York	A	dsl	825	Emsco GC-500	825	10,000
EDDY COUNTY						
Carper Drlg Co Inc	4	gas-btne	650	Beth S-55	560	6,000
	5	gas-btne	675	M-CSCO U-15	675	8,000
Davey O'Brien Drlg Co Inc	4	gas-btne	280	Wlsn Spr	145	3,000
Delta Drlg Co	3	gas-btne	900	Natl 100	800	12,000
Dual Drlg Co	6	gas	250	Emsco GA250T	300	5,000
Great Western Drlg Co	9	gas	1053	M-CSCO U-20	1600	16,000
	11	dsl	353	Wlsn Gnt Rdmstr	900	9,000
Johnn Drlg Co Inc	4	gas	375	M-CSCO U-15	600	8,500
Rowan Drlg Co Inc	16	gas-btne	504	Natl 50	660	7,000
Walters Drlg Co Inc	7	gas	175	Mayhew 1000	175	900/2-3/8"
S P Yates Drlg Co	2	dsl	350	M-CSCO U-15	540	6,500
	3	dsl	350	Natl T-12	250	4,000
LEA COUNTY						
Brantly Drlg Co Inc	3	gas	700	Brwstr N-75	750	11,000
	7	gas	975	Beth 450	1125	12,500
Davidson Drlg Co Inc	C	btne	660	Emsco GC-500	660	8,500
Dillard-Waltermire Inc	9	gas	800	Natl 100	1200	11,500
Great Western Drlg Co	2	gas-gaso	500	Wlsn Gnt Rdmstr	840	9,000
	25	gas-gaso	275	M-CSCO U-914A	1530	15,000
Helmerich & Payne Inc	32	gas	1100	"Oilwell" 96	1100	14,000
	41	gas	1200	Natl 110	1500	15,000
Kerr-McGee Oil Ind Inc	7	gas	900	Natl 75	818	11,500
King-Phillips Inc	4	gas	700	Beth S-45E	350	6,500
Llano Drlg Co	5	gas	–	Natl 100	1050	14,000
Lowe Drlg Co	6	gas	1000	Natl 100	1000	12,500
	8	gas	1500	Natl 80	1500	15,000
	9	gas	2000	Natl 125	2000	17,000
Marcum Drlg Co	5	gas-btne	1000	Brwstr N-95	1525	14,000
McQueen & Stout Drlg Co	11	LPG	225	Crdwll RL	185	4,500
	15	LPG	225	Crdwll RL	185	4,500
Moran Oil Prod & Drlg Corp	4	gas	–	M-CSCO U-34	300	5,000
Parker Drlg Co	45	gas	–	Natl 125	1400	15,000
	49	gas	–	Natl 125	1400	15,000
	51	gas	–	Natl 50	700	9,000
Pico Drlg Co	4	gas-btne	180	Wlsn Mogul	300	4,000
Robinson Bros Drlg Co	2	gas	800	Brwstr N-75	800	10,000
Western Serv Drlg Co Inc	8	gas-btne	600	Beth MC-650	700	11,000
	11	gas-btne	1000	Beth 810	1100	11,000
S P Yates Drlg Co	1	dsl	350	M-CSCO U-34	350	5,000
RIO ARRIBA COUNTY						
Arapahoe Drlg Co	1	gas-btne	300	Natl T-32	320	6,000
	3	gas-btne	300	Wlsn Mogul	275	5,000
	7	gas-btne	550	M-CSCO U-15	550	8,500
Carroll Drlg Co Inc	10	gas-btne	300	Emsco GA 350	675	6,500
Great Western Drlg Co	32	gas	353	M-CSCO U-15	750	7,500
Hondo Drlg Co	3	gas	675	M-CSCO U-15	675	7,500
Moran Bros Inc	15	gas	400	Natl T-20	390	6,000
Rutledge Drlg Co	2	gas-btne	675	Beth M-58	850	10,000
ROOSEVELT COUNTY						
Brantly Drlg Co Inc	8	gas	675	Beth 450	870	11,500
Frank Frawley Drlg Co	2	gas	–	M-CSCO U-20	1050	13,000
SAN JUAN COUNTY						
Brannon & Murray Drlg Co	1	gas-LPG	550	Brwstr N-55	550	8,500
	2	gas-LPG	550	Emsco GA-350	550	6,500
	3	gas-LPG	350	Brwstr N-4	250	5,000
	4	dsl	300	Brwstr N-4	300	5,500
Brinkerhoff Drlg Co	24	dsl	375	Natl T-20	275	5,500
Calvert Drlg Inc	20	dsl	350	Ideco H-525	600	8,500
Carroll Drlg Co Inc	6	gas-btne	300	M-CSCO U-15	732	7,500
	8	gas-btne	495	Natl-75	680	8,500
Empire States Drlg Corp	1	gas	225	M-CSCO U-34 Trlr	225	5,000
	2	gas	530	Ideco H-35	530	6,500
	3	gas	225	Crdwll L	225	4,000
Exeter Drlg Co	3	btne	630	Natl 50-A	630	8,500
Exploration Drlg Co	10	gas	525	M-CSCO U-15	400	8,000
Foree Drlg Co	1	gas-btne	325	M-CSCO U-34	300	4,500
	3	gas-btne	325	M-CSCO U-15	600	7,500
	5	btne	350	"Oilwell" 52-T	426	6,000
Gardner Bros Drlg Co Inc	17	gas-btne	550	Natl 50-A	700	8,500
	19	gas-btne	185	Crdwll R	200	3,300
	21		250	Wilson Mogul	250	4,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Avail able to Drwwks	Rated Depth with 4½" Pipe
Great Western Drlg Co	20	dsl	265	Frnks SAL-1600	600	5,500
Herndon Drlg Co	4	gas	480	Emsco G-450	630	7,000
Moran Bros Inc	7	gas	900	Wlsn Gnt	750	9,500
Rutledge Drlg Co	7	gas-btne	375	M-CSCO U-15	600	8,000
STOREY COUNTY						
Barnes Core Drlg Co	D-6	dsl	450	Custom	450	5,500 /3-1 /2"
NEW YORK						
TOMPKINS COUNTY						
Delta Drlg Co	39	gas-btne	500	Natl 75	1000	9,500
NORTH CAROLINA OLINA						
NEW HANOVER COUNTY						
Burton Drlg Co	7	gas-gaso	–	–	–	2,500
ONSLOW COUNTY						
Taylor Expl Co Inc	8	btne	–	Failing	–	2,000
NORTH DAKOTA A						
BILLINGS COUNTY						
Helmerich & Payne Inc	15	dsl	975	"Oilwell" 76	1000	11,000
Rutledge Drlg Co	3	gas-btne	900	Beth 450	850	12,500
BURKE COUNTY						
Cactus Drlg Corp Ltd	1	gas-btne	450	Brwstr N-55	450	7,000
	2	gas-btne	675	M-CSCO U-15	675	8,500
Calvert Drlg Inc	22	gas-btne	320	Ideco H-35	330	5,500
	23	dsl	350	Ideco H-525	600	8,500
	24	gas-btne	600	M-CSCO U-15	600	9,000
	25	gas-btne	1050	Beth 810	1100	12,500
Exploration Drlg Co	8	gas	725	M-CSCO U-15	600	8,000
L & J Drlg Ltd	1	dsl	300	Natl 50	300	7,500
Lohmann-Johnson Drlg Co Inc	1	dsl	300	Natl 50	480	5,500
M-H-O- Drlg Co	8	gas-btne	800	M-CSCO U-15	800	8,000
	9	dsl	850	Crdwll D	400	7,000 4"
Penrod Drlg Co	19	dsl	795	Brwstr N-7	700	10,000
DIVIDE COUNTY						
Rutledge Drlg Co	6	gas-btne	362	Emsco 350	675	8,000
McHENRY COUNTY						
Exploration Drlg Co	9	gas	310	Beth S-50	225	5,500
McKENZIE COUNTY						
Brinkerhoff Drlg Co	5	dsl	650	Emsco J-750	800	10,000
Calvert Drlg Inc	26	gas-btne	1380	Natl 80-B	1380	14,000
Cabe McCall Drlg Co	3	gas	1200	Natl 80	1200	10,000
Penrod Drlg Co	31	dsl	920	Brwstr N-75	830	11,000
Rowan Drlg Co Inc	5	gas-btne	840	Natl 75	1120	11,000
	15	gas-btne	1140	Natl 75	1503	11,000
	23	gas-btne	1140	Natl 75	1503	11,000
Rutledge Drlg Co	1	gas-btne	960	Beth 810	1257	15,000
RENVILLE COUNTY						
Exploration Drlg Co	6	gas	310	Beth S-50	225	5,500
WILLIAMS COUNTY						
Penrod Drlg Co	5	dsl	1200	Emsco A-1100	1575	15,000
Rowan Drlg Co Inc	27	gas-btne	1350	Natl 125	1530	15,000
OHIO						
HOLMES COUNTY						
Walter W Willis	2	dsl	278	Natl T-12	237	4,500
MORGAN COUNTY						
Walter W Willis	5	dsl	–	Beth S-45E	–	4,500
TUSCARAWAS COUNTY						
Glenn Gillespie & Sons	7	dsl	300	Frnks 658 TRD	225	4,000
WAYNE COUNTY						
D J Branyan Co	1	dsl	600	Wichtex E-75	145	3,000
OKLAHOMA						
ALFALFA COUNTY						
Big Chief Drlg Co	1	gas	450	JS&G Spad "Super"	450	6,500
Davon Drlg Co	1	gas-LPG	250	Brwstr N-4	320	6000 /3-1 /2"
	2	gas-LPG	380	Brwstr N-4	320	6,500
	5	gas-LPG	400	Brwstr N-45	430	7,500
Lohmann-Johnson Drlg Co Inc	8	dsl	300	Natl 32	550	7,500
Viersen & Cochran	14	gas	325	Natl T-25	225	5,500
Warren Drlg Co	1	gaso	395	Natl T-32	500	7,500
BEAVER COUNTY						
Arrow Drlg Co	11	dsl	595	Emsco 500	–	8,000
Baker & Taylor Drlg Co	2	dsl	800	M-CSCO U-15	800	8,500
	6	gas-btne	750	Emsco G-450	750	9,500
Beckman Inc	17	(wo) gas	150	MIW P-42	200	10,000 2-7/8"
	18	(wo) gas	150	MIW P-42	200	10,000 2-7/8"
Big Chief Drlg Co	27	gas	760	JS&G Spad Spr	760	9,000
D & M Drlg Co Inc	2	gas-btne	650	M-CSCO U-15	650	9,000
Harper-Turner Drlg Co	8	gas	480	Natl 50	–	8,000
Helmerich & Payne Inc	36	gas	500	Emsco GB-50052	700	9,000
Lynn Drlg Co	5	gas-btne	725	Natl 75	900	10,500
Midwestern Drillers Inc	7	dsl	370	M-CSCO U-15	750	8,500
Moran Bros Inc	4	gas	1000	Wlsn Titan	1200	14,000
R W Rine Drlg Co	3	gas-btne	520	Brwstr 55	600	7,500
	4	dsl	620	Brwstr N-75	750	9,500
Service Drlg Co	15	gas	750	Wlsn Gnt	350	7,000
Viersen & Cochran	1	gas	675	Natl 50	450	8,000
Earl F Wakefield	4	gas-btne	750	Wlsn Gnt Rdair	750	9,500
Tommy Ward Drlg Co	1	gas-btne	300	M-CSCO U-15	480	8,000
BECKHAM COUNTY						
Big Chief Drlg Co	33	gas	1250	Natl 55	1250	11,000
Helmerich & Payne Inc	47	gas-btne	2000	"Oilwell" 96-16	2000	20,000
BRYAN COUNTY						
Hoffman Drlg Co	6	gas	750	Wlsn Atlas	950	10,000
CADDO COUNTY						
Arrow Drlg Co	25	gas	840	Ideco 1000	–	10,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Avail- able to Drwwks	Rated Depth with 4½" Pipe
Glendale Drlg Co	1	gas-gaso-btne	320	M-CSCO U-10	330	5,000
Graham Drlg Co	1	gas-btne	235	Wlsn Mogul	285	5,000
Harper-Turner Drlg Co	9	gas	125	Crdwll	–	4,000
CANADIAN COUNTY						
Kirkpatrick Oil Co	4	gas	300	Wlsn Giant	504	10,500
CARTER COUNTY						
Kingery Drlg Co Inc	10	btne-gas	300	Wilson	375	4,500
Kirkpatrick Oil Co	1	gas	300	Beth S-60	336	7,500
Parker Drlg Co	55	gas-elec	–	Emsco 750	2000	10,000
Perkins Drlg Co	3	gas-btne	400	Beth S-60	370	7,500
Sherin Drlg Co	5	gas-gaso	750	Natl 55	750	9,000
J D Speer	1	dsl	104	Wlsn Spr	104	2,500 /3-1 /2"
Viersen & Cochran	9	gas	1300	Emsco J-1250	1590	18,000
CIMMARON COUNTY						
Graham-Michaelis Drlg Co	1	dsl	275	Beth Twister	500	6,500
Holm Drlg Co	5	dsl	300	"Oilwell" 52 T	300	5,500
Wagner & Wyant Drlg Co Inc	1	dsl	300	M-CSCO U-15	675	8,000
CLEVELAND COUNTY						
Davon Drlg Co	3	gas-LPG	500	Brwstr N-7	750	10,000
Garr-Woolley Co	2	gas-btne	255	Emsco 350	378	7,000
Nuckolls-Bell Drlg Co	3	dsl	600	Ideco H-525	704	9,000
Perkins Drlg Co	4	gas-btne	1200	Beth 650	1200	12,000
COAL COUNTY						
Goff-Leeper Drlg Co	3	gas	450	M-CSCO U-15	450	8,000
Sherin Drlg Co	4	gas-gaso	1000	Natl 100	1050	12,000
COMANCHE COUNTY						
C N P Drlg Co	1	gas	185	Wichtex	145	3,500
COTTON COUNTY						
R V Dillard Drlg Co	1	gas	–	Wichtex	145	3,000
CREEK COUNTY						
Indian Drlg Co	1	btne	220	Ideco H-25	250	4,000
Mesker Drlg Co	1	gas	214	Joy 300	170	2,500
	2	gas	185	Joy 300	160	2,500
Reed Drlg Co Inc	3	gas-gaso	180	M-CSCO U-34	180	3,200
Wade Drlg Co Inc	1	dsl	225	Crdwll L	185	3,500
DEWEY COUNTY						
Calvert Drlg Inc	28	–	–	Natl 80-B	1650	12,500
Helmerich & Payne Inc	24	gas	950	Natl 80	1100	11,000
Service Drlg Co	16	gas	1600	Wlsn Super Titan	1600	18,000
Viersen & Cochran	11	gas	1525	Natl 110	1530	18,500
ELLIS COUNTY						
Big Chief Drlg Co	36	gas	800	Natl 55	800	11,000
J S Montgomery	3	gas	1100	Natl 80	1100	12,000
Parker Drlg Co	56	gas	–	Natl 50	700	9,000
GARFIELD COUNTY						
Big Chief Drlg Co	24	gas	750	M-CSCO U-15	800	9,500
Hayward Drlg Co	1	gas	200	Wilson	125	2,500
O'Rourke-McGirl Drlg Co	1	gas-btne	–	M-CSCO U-10	450	6,000
GARVIN COUNTY						
An-Son Drlg Co	7	gas	1085	Wlsn Atlas	900	10,500
Big Chief Drlg Co	5	gas	1545	Emsco 1250	1545	15,000
	30	gas	1545	Ideco 1050	1515	15,000
Big X Drlg Co Inc	2	gas-btne	750	Natl 55	750	10,000
Garr-Woolley Co	4	gas-btne	1020	Emsco 500-GC	510	10,000
Goff-Leeper Drlg Co	4	gas	850	Wlsn Giant	850	12,500
Helmerich & Payne Inc	44	gas	1200	"Oilwell" 96	1500	15,000
Sherin Drlg Co	1	gas-gaso	500	M-CSCO U-15	600	8,000
	2	gas-gaso	500	M-CSCO U-15	600	8,000
Viersen & Cochran	3	gas	600	Natl 75CA	800	10,500
GRADY COUNTY						
Big Chief Drlg Co	35	gas	2610	Natl 110	2610	16,000
Dick Wegener Drlg Co	4	gas-dsl	1900	Natl 130	1900	22,000
GRANT COUNTY						
Barrett Petroleum Co	2	gas-gaso	–	Natl 50	450	7,500
R L Horn & Sons Drlg Co	5	gas	185	M-CSCO U-34	185	5,500
Viersen & Cochran	12	gas	325	Natl T-25	225	5,500
HARPER COUNTY						
An-Son Drlg Co	2	gas	875	M-CSCO U-15	700	9,000
Arrow Drlg Co	20	gas	460	Emsco 350	–	7,000
Barrett Petroleum Co	1	gas-gaso	–	Natl 50	450	7,500
Beckman Inc	19	(wo) –	180	MIW P-42	175	10,000
Calvert Drlg Inc	21	dsl	350	Ideco H-35	260	6,500 /4"
Dudley & Heath Drlg Co	7	dsl	265	Brwstr N-4	320	5,500
T T Eason Co Div Eason Oil Co	14	gas	750	Emsco GB-500	940	9,500
	15	gas	750	Emsco T-250	450	6,300
Helmerich & Payne Inc	46	gas	500	Emsco GB-500-52	700	9,000
Service Drlg Co	3	gas	600	M-CSCO U-15	600	8,500
	12	gas	900	Wlsn Atlas	600	10,000
Unit Drlg Co	2	gas-btne	900	M-CSCO U-15	900	8,500
Viersen & Cochran	5	gas	725	Natl 50	800	9,000
	10	gas	675	Natl 50	450	8,500
HUGHES COUNTY						
E L & M Drlg Co	1	gas	450	Wlsn Mogul	–	4,500
Goff-Leeper Drlg Co	2	gas	225	Brwstr N-4	350	6,000
R W I T Drlg Co	1	gas-LPG	150	Crdwll	150	3000 /3-1 /2"
JOHNSTON COUNTY						
Helmerich & Payne Inc	38	gas	950	Natl 80	1100	11,000
KAY COUNTY						
Dudley & Heath Drlg Co	6	dsl	265	Crdwll S	320	5,500
Dave Morgan Drlg Co	–	LPG-gas	350	Natl T-32	320	6,000
Pete Morris Drlg Co	1	dsl-gas	550	Wlsn Giant	550	6,000
Reed Drlg Co Inc	1	gas-gaso	220	M-CSCO U-34	235	5,000
Target Drlg Corp	1	gas-btne	225	M-CSCO U-34	195	5,000
KINGFISHER COUNTY						
Calvert Drlg Inc	19	dsl	350	M-CSCO U-15	600	8,500
	27	–	–	Wlsn Spr	–	12,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
LATIMER COUNTY						
Viersen & Cochran	7	gas	1070	M-CSCO U-712-A	1200	15,000
LINCOLN COUNTY						
Frizzell Drlg Co	1	gas-gaso	–	Wilson	600	7,500
Harper-Turner Drlg Co	5	gas	320	Emsco G-300	–	6,000
Indian Drlg Co	2	dsl	220	Ideco H-35-S	350	5,000
Johnson-Bates Drlg Co	2	gas	325	M-CSCO U-34	245	6,500
Lincoln Drlg Co	1	gas	250	Brwstr N-3	185	4,500
Wade Drlg Co Inc	3	dsl	325	Crdwll L	225	4,500
Warren Drlg Co	2	dsl	320	Ideco H-30S	300	5,000
LOGAN COUNTY						
Nuckolls-Bell Drlg Co	2	dsl	300	Ideco H-40	352	7,500
MAJOR COUNTY						
Calvert Drlg Inc	18	gas-btne	–	M-CSCO U-15	585	8,500
MARSHALL COUNTY						
Halliman Drlg Co	1	gas	500	M-CSCO U-15	900	7,500
	6	gas	750	Wlsn Atlas	950	11,000
Tom Jack Drlg Co	4	dsl	200	Crdwll S-350	200	5,000/3-1/2"
Sikes-Burckhalter Drlg Co	1	–	500	Wlsn Giant	750	8,500
	2	–	500	Wlsn Atlas	750	10,000
McCLAIN COUNTY						
An-Son Drlg Co	6	gas	875	M-CSCO U-15	700	9,000
	7	gas	1085	Wlsn Atlas	900	10,500
Bryant-Hayward Drlg Co	2	gas	675	Natl 50	675	8,500
T T Eason Co Div Eason Oil Co	12	gas	1000	Natl 80-B	1060	12,500
Goff-Leeper Drlg Co	5	gas	850	Ideco H 7-11	850	13,000
Hap Drlg Co	1	gas	1000	Wilson Atlas	1000	12,000
Halliman Drlg Co	5	dsl	825	Emsco GB-800	1000	11,000
Kerr-McGee Oil Ind Inc	16	gas	895	Natl 100	1248	12,500
Lynn Drlg Co	3	gas-btne	1000	Natl 100	1000	14,500
Nuckolls-Bell Drlg Co	4	gas	1000	Natl 80-B	1000	13,000
Parker Drlg Co	30	gas	–	Natl 50	700	9,000
	34	gas	–	Natl 75	800	10,000
	37	gas	–	Natl 100	1400	14,000
	38	gas	–	Natl 100	1000	14,000
Viersen & Cochran	2	gas	500	Natl 55	800	10,500
	4	gas	600	Natl 75	800	10,500
	8	gas	1250	Emsco J-1000	1200	14,000
Chester H Westfall Drlg Co	1	gas-gaso	625	M-CSCO U-15	700	10,400
	2	gas-gaso	625	M-CSCO U-15	700	10,400
	3	gas-gaso	625	M-CSCO U-15	700	10,400
McINTOSH COUNTY						
Reed Drlg Co Inc	4	gas-gaso	300	M-CSCO U-34	290	5,000
MURRAY COUNTY						
Bryant-Hayward Drlg Co	1	gas	675	Natl 50	675	8,500
Service Drlg Co	14	gas	1300	Wlsn Titan	1000	14,000
NOBLE COUNTY						
Barrett Petroleum Co	4	dsl	–	M-CSCO U-10	350	5,800
Garr-Woolley Co	1	gas-btne	185	Emsco 300	280	5,500
Lincoln Drlg Co	2	gas	325	Emsco 250	290	6,000
The Novak Drlg Co	3	gas	265	Brwstr N-45	–	5,000
Unit Drlg Co	3	dsl	700	Natl 50-A	700	6,500
OKFUSKEE COUNTY						
Johnson-Bates Drlg Co	1	gas	245	M-CSCO U-34	300	5,000
Sabre Drlg Co	2	dsl	330	M-CSCO U-34	300	5,000/4"
	4	gas-LPG	225	Brwstr N-3	160	3,500/4"
Unit Drlg Co	1	gas-btne	290	M-CSCO U-34	300	5,500
OKLAHOMA COUNTY						
Big X Drlg Co Inc	1	gas-btne	750	Beth MC-450	250	10,000
Garr-Woolley Co	3	gas-btne	320	Emsco 500-GB	510	9,500
Harper-Turner Drlg Co	2	gas	450	Natl 50	–	7,500
	4	gas	450	Natl 50	–	7,500
O'Neal-Garvin Drlg Co	2	–	500	M-CSCO U-15	–	8,500
	4	–	–	Emsco 500	–	10,000
Sabre Drlg Co	3	dsl	285	M-CSCO U-36	560	7,500/4"
OKMULGEE COUNTY						
Seran & Howard Drlg Co	1	gas	225	Beth	200	5,000
OSAGE COUNTY						
Doak Drlg Co	2	btne-gas	270	Natl T-20	250	4,500
Glenn Gillespie & Sons	1	gas	360	M-CSCO U-34	225	4,500
	3	dsl	425	Wlsn Mogul	280	6,000
Al Johnson Drlg Co	2	btne	325	Mayhew	200	3,500
Reed Drlg Co Inc	6	gas-gaso	240	Natl T-12	180	4,500
Service Drlg Co	9	dsl	250	Natl T-12	180	4,000
	11	gas	220	Crdwll AH	150	3,000
PAWNEE COUNTY						
Doak Drlg Co	3	btne-gas	270	Natl T-20	250	4,500
Roy Lawrence Drlg Co	1	dsl	350	Frnks Comet	240	5,500/3-1/2"
PAYNE COUNTY						
Davon Drlg Co	4	gas-LPG	200	Brwstr N-2	320	6,500/2-7/8"
Sabre Drlg Co	1	gas	290	T-20	240	5,500
POTTAWATOMIE COUNTY						
Barrett Petroleum Co	3	dsl	–	Wlsn Giant	300	5,500
The Novak Drlg Co	2	gas	300	M-CSCO U-10	–	6,500
Viersen & Cochran	13	gas	325	Natl T-16	175	5,200
SEMINOLE COUNTY						
Delaney Drlg Co	2	gas-btne	240	M-CSCO U-34	230	5,500
Jonco Drlg Co	1	gas-gaso	300	Emsco 160	200	5,000
	2	gas-gaso	300	Crdwll S	175	5,000
Kingery Drlg Co Inc	3	dsl	210	Wilson	350	4,500
Melco Drlg Co	1	btne	265	Brwstr N-35	185	5,000
	2	btne	265	Brwstr N-35	185	5,000
Reed Drlg Co Inc	2	gas-gaso	–	Crdwll D	410	5,500
Troup & Suttles Inc	2	gas-gaso	200	Wilson	370	5,000
STEPHENS COUNTY						
Bryant-Hayward Drlg Co	4	gas	900	Brwstr N-75	900	12,000
Goff-Leeper Drlg Co	1	gas	800	Brwstr N-75	800	12,000

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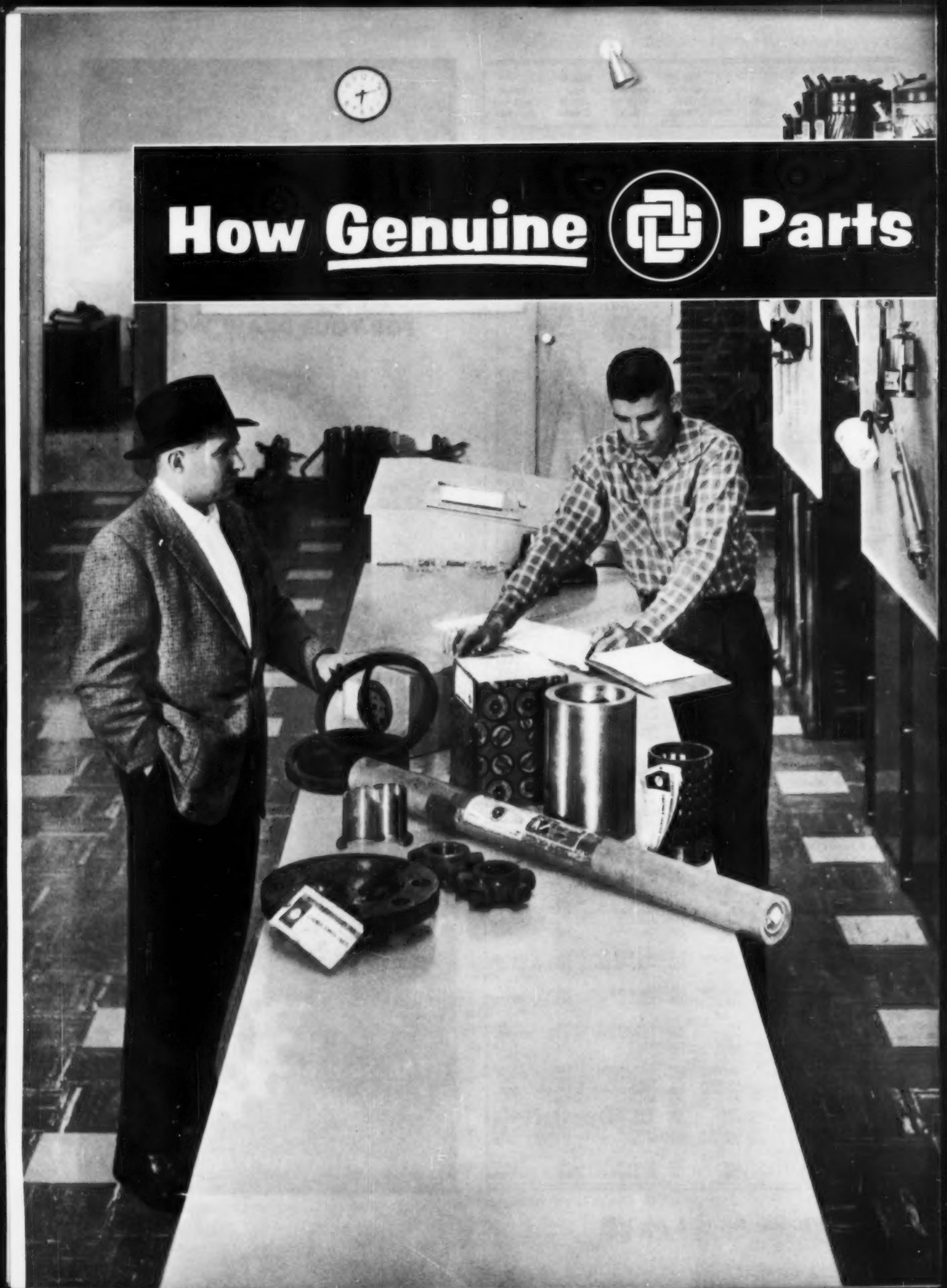
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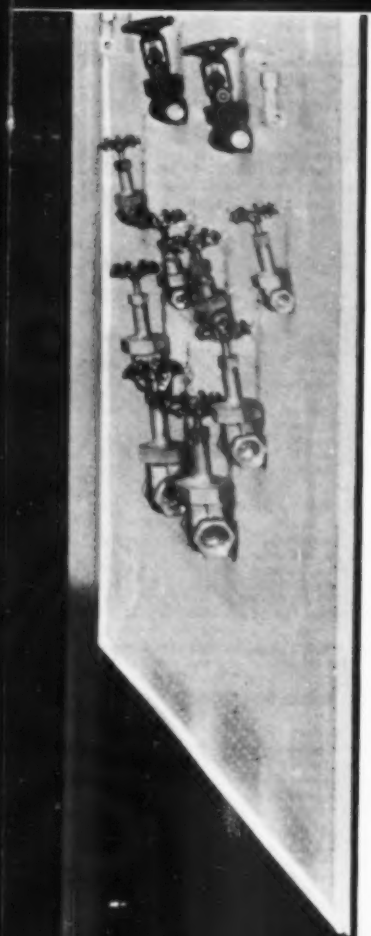

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- Insure long trouble-free service.
- Prevent damage from mismatched parts.

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These parts will protect your investment in superior performance.

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DRILLING EQUIPMENT: JONES & LAUGHLIN DRILL PIPE, CASING AND WIRE ROPE, GARDNER-DENVER MUD PUMPS, IDECO DRILLING RIGS, REPUBLIC ROTARY HOSE.

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Holliman Drlg Co	2	gas	350	M-CSCO U-15	550	7,500
	4	gas	255	M-CSCO U-15	500	7,500
Tom Jack Drlg Co	5	dsl	200	Crdwll S-350	200	5,000
O'Neal-Garvin Drlg Co	3	–	–	Natl 50	–	7,500
Perkins Drlg Co	2	gas-btne	–	M-CSCO U-15	675	8,500
Pierco Drlg Co	1	gas-LPG	400	Wlsn Mogul	165	4,200
Quad Drlg Co	1	btne	300	Frnks Gnt Clipr	274	5,000
	2	btne	140	Crdwll KL-146	140	3,000
TEXAS COUNTY						
Beckman Inc	5	(wo)	–	MW P-42	175	10,000
Graham-Michaelis Drlg Co	5	dsl	275	Crdwll B	275	4,000
Holm Drlg Co	6	dsl	750	Wlsn Roadair	600	8,500
Midwestern Drillers Inc	2	dsl	320	M-CSCO U-15	600	7,500
	3	dsl	370	M-CSCO U-15	750	8,500
Moran Bros Inc	2	gas	700	Emsco GA-500	750	9,500
	6	gas	900	Wlsn Gnt	750	9,500
Earl F Wakefield	3	dsl	440	Wlsn Gnt Rdair	440	6,000
	6	dsl	960	Wlsn Atlas Rdair	960	13,000
TILLMAN COUNTY						
E W Moran Drlg Co	2	gas	500	Wlsn Giant	650	7,500
WASHINGTON COUNTY						
The Novak Drlg Co	1	gas	225	Brwstr N-4	–	3,500
WASHITA COUNTY						
Sherin Drlg Co	3	gas-gaso	500	M-CSCO U-15	600	8,000
WOODS COUNTY						
Branyan Drlg Co	2	dsl	700	Beth	700	9,000
Glenn Gillespie & Sons	6	gas	290	M-CSCO U-34	290	4,500
WOODWARD COUNTY						
Barrett Petroleum Co	5	gas-gaso	–	Brwstr N-7	750	8,500
Harper-Turner Drlg Co	1	gas	650	Wlsn Titan	–	11,000
Service Drlg Co	17	gas	900	Wlsn Atlas	600	10,000
PENNSYLVANIA						
S W Jack Drlg Co	1	gas	635	M-CSCO U-15	635	8,500
CLEARFIELD COUNTY						
Delta Drlg Co	30	dsl	670	Emsco G-500	500	8,500
Fairman Drlg Co	1	gas-btne	500	Beth M-58	600	10,000
	2	gas-btne	500	"Oilwell" 66	600	9,000
	3	gas-btne	500	Wlsn Gnt	600	9,000
S W Jack Drlg Co	3	gas	650	M-CSCO U-15	650	8,500
Lohmann-Johnson Oil Co Inc	10	dsl	–	M-CSCO U-15	500	6,000
CLINTON COUNTY						
Delta Drlg Co	27	dsl	380	Emsco GA-350	350	6,000
ELK COUNTY						
Delta Drlg Co	24	dsl	670	Emsco GC-500	500	8,500
INDIANA COUNTY						
Delta Drlg Co	34	gas-btne	800	M-CSCO U-15	600	8,000
SOMERSET COUNTY						
Delta Drlg Co	10	dsl	560	M-CSCO U-15	560	7,000
SOUTH DAKOTA						
FALLS RIVER COUNTY						
Branyan Drlg Co	1	dsl	600	Frnks 6000	600	6,000
HARDING COUNTY						
Hewit-Gulick Drlg Co	1	dsl	970	Natl 50-A	600	8,000
TENNESSEE						
CLAY COUNTY						
Hack Drlg Co	4	btne	–	–	161	2,500
TEXAS						
Dillard-Waltermire Inc	3	stm	800	Natl 23-9FM	1000	12,000
J E Jones Drlg Co	3	gas	700	"Oilwell" 76	855	12,000
ANDERSON COUNTY						
Robert M Bass Drlg Contr	5	gas-LPG	300	Wlsn Giant	300	5,500
M J Delaney Co	29	gas-btne	500	Beth 450	750	11,000
W B Hinton	3	dsl	–	M-CSCO U-	–	12,000
Trant Drlg Co	2	dsl	500	Ideco M-10,000	1000	12,000
Travis Ward Drlg Co	1	dsl	600	Wlsn Gnt	300	6,500
ANDREWS COUNTY						
B B M Drlg Co	5	gas-btne	1100	Emsco J-750	800	12,800
	6	gas-btne	1050	Emsco GB-500	650	10,000/3-1/2"
Beckman Inc	11	(wo) gas	300	M-CSCO U-34	300	4,500
L E Bever Drlg Co	1	gas	225	M-CSCO U-34	225	5,500
	U-34	–	–	M-CSCO U-34	225	–
Big West Drlg Co	11	gas-btne	500	M-CSCO U-20	900	14,000
Brantly Drlg Co Inc	6	gas	400	Natl 50	750	9,000
M J Delaney Co	19	gas-btne	600	Emsco J-1250	1200	15,000
	27	gas-btne	500	Beth 450	850	11,000
The Denver Co	1	gas	335	Natl T-20	300	5,500
Dillard-Waltermire Inc	10	gas	600	Wlsn Giant	800	8,000
Durham Drlg Co Inc	3	gas	1150	M-CSCO U-20	1300	14,000
Frank Frawley Drlg Co	3	gas	–	Natl 100	1050	13,000
Fryer & Hanson Drlg Co	4	gas-btne	1150	"Oilwell" 76	1200	12,000
	11	gas-btne	1200	Beth M-58	1200	12,000
Gardner Bros Drlg Co Inc	10	gas-btne	750	Natl 100	1050	12,500
Great Western Drlg Co	17	gas-gaso	765	M-CSCO U-914B	1260	15,000
	21	gas-gaso	840	M-CSCO U-914A	1260	15,000
	27	gas-gaso	853	M-CSCO U-914A	1125	15,000
	40	gas	450	Wlsn Atlas	840	10,000
O E Hall Drlg Co	1	gas	320	M-CSCO U-15	700	8,000
Helmerich & Payne Inc	9	gas	1200	"Oilwell" 96	1100	14,000
La Mance Drlg Co	2	btne	700	M-CSCO U-15	–	9,500
Lowe Drlg Co	3	gas	1000	Wilson	1000	12,500
	7	gas	1250	Natl 100	1250	12,500
	10	gas	1800	Natl 125	1800	17,500
Marcum Drlg Co	6	gas-btne	900	Natl 75	1050	10,000
Davey O'Brien Drlg Co Inc	1	gas-btne	700	Emsco GA-500	700	8,500
Parker Drlg Co	4	gas	–	Natl 100	1400	14,000
	41	gas	–	Natl 100	1400	14,000
	42	gas	–	Natl 100	1400	14,000
	43	gas	–	"Oilwell" 96	1400	15,000
	47	gas	–	Natl 100	1400	14,000
	54	gas	–	Natl 125	1400	20,000
	58	gas	–	Natl 100	1400	14,000
Fred Pool Drlg Co	2	gas	870	M-CSCO U-15	870	8,500
	3	gas	290	M-CSCO U-10	225	5,500
Robinson Bros Drlg Co	3	gas	300	Brwstr N-55	500	6,500
	4	gas	300	Brwstr N-45	450	6,500
Rowan Drlg Co Inc	12	gas-btne	1260	Natl 100	1680	14,000
	22	gas-btne	600	Natl 50	766	7,000
Warton Drlg Co	3	gas	1620	Natl 110	1600	14,000
ARANSAS COUNTY						
Bass Drlg Co	1	gas-gaso-btne	675	M-CSCO U-15	–	10,000
Camden Drlg Co	1	dsl	300	Natl T-20	300	5,000
ARCHER COUNTY						
Akin & Dimock	2	dsl	300	Beth S-55	420	7,000
Jack Grace Drlg Co	17	gas-btne	370	Wlsn Giant	700	8,000
Graytex Drlg Co	1	gas	325	Natl T-32	400	6,500
Sheets & Walton Drlg Co	3	pwr	365	Brwstr N-4	285	5,000
ATASCOSA COUNTY						
Buzzini Drlg Co	8	gas-btne	1920	Wlsn Titan	1210	14,000
	9	gas-btne	1150	Wlsn Titan	1210	14,000
General Well Drlg Inc	8	btne	400	Brwstr N-4	185	4,500/3-1/2"
BASTROP COUNTY						
Hunt Drlg Co Inc	5	gas	1680	Beth MC-650	1200	16,000
Pegg Bros Drlg Co	1	gas-btne	145	Brwstr	145	4,500/3-1/2"
BEE COUNTY						
Appell Petroleum Corp	3	gas-gaso	510	Brwstr N-4	225	6,000
J & C Drlg Co	8	gas-btne	800	Beth 650	800	12,000
BEXAR COUNTY						
Walters Drlg Co Inc	9	gas	130	Mayhew 1000	130	800/2-3/8"
BORDEN COUNTY						
Great Western Drlg Co	35	dsl	300	M-CSCO U-15	760	7,500
O E Hall Drlg Co	3	gas	600	M-CSCO U-15	700	8,000
Hewgley Drlg Co	4	gas-btne	–	Emsco GA-500	650	8,500
	6	gas-btne	–	Emsco GB-500	650	9,000
Johnn Drlg Co	8	gas	500	Brwstr N75	700	10,000
Petroleum Drlg Co	–	gas	900	Wlsn Atlas	1000	10,000
Pico Drlg Co	8	gas-btne	756	Beth M-58	925	10,500
Rheay & Reynolds Drlg Co	4	gas	350	Natl 50	1200	7,000
	5	gas	350	Natl 75	1200	7,000
West Central Drlg Co	5	gaso-btne	325	M-CSCO U-15	600	7,500
BOWIE COUNTY						
Maxwell Herring Drlg Corp	2	gas	700	Wlsn Gnt Rdair	700	10,500
BRAZORIA COUNTY						
Continental Marine Expl Co	5	gas-btne	1480	Wlsn Titan	700	12,000
Dillard-Waltermire Inc	5	stm	800	Natl 23-9FM	1000	12,000
C J Foster Drlg Co Inc	9	gas-LPG	–	Wlsn Giant	412	8,000
Grey Wolf Drlg Co	2	dsl-elec	1250	Emsco ECA	1250	18,000
	4	gas-btne	585	Emsco GB-500	–	9,500
Mac Drlg Co	12	stm	500	Natl 23-9-FED	1000	20,000
BROOKS COUNTY						
Fitzpatrick Drlg Co	4	gas	1050	Beth Tornado	1000	13,000
Well Drillers Inc	1	gas-gaso-btne	1140	Natl 75	964	10,000
CALDWELL COUNTY						
Bay City Drlg Co Inc	2	gas-btne	300	M-CSCO U-34	300	5,000
Pegg Bros Drlg Co	2	gas-btne	110	–	110	3,000/3-1/2"
CALHOUN COUNTY						
Field Drlg Co	3	dsl	1110	Emsco 500	520	10,000
C J Foster Drlg Co Inc	4	gas-LPG	–	Prtble CT-5	550	8,500
Grey Wolf Drlg Co	1	gas-btne	945	Emsco GB-800	–	12,500
Howard Parker Co	2	gas-btne	500	Crdwll D	750	9,500
Layton Brown Drlg Co Bge	2	dsl	–	–	800	10,000
	3	stm	–	–	1050	10,000
CALLAHAN COUNTY						
Low Drlg Co	3	btne	–	Wilson	165	2,500
CAMERON COUNTY						
Layton Brown Drlg Co Bge	4	dsl	1850	"Oilwell" 96	1100	16,000
CAMP COUNTY						
W B Hinton	2	dsl	–	M-CSCO U-15	350	12,000
CARSON COUNTY						
Drlg & Expl Co of Del Inc	25	gas	225	Frnks 137/33 DTDX	400	5,000
CASS COUNTY						
Butler-Johnson Inc	3	gas-btne	400	Brwstr N-45	400	7,000
	4	gas	500	Brwstr N4	350	6,500
M J Delaney Co	28	gas-btne	500	"Oilwell" 96	1000	14,000
Maxwell Herring Drlg Corp	1	gas	300	Wlsn Mogul	400	6,000
Travis Ward Drlg Co	2	dsl	1550	Wlsn Titan	1100	12,500
CHAMBERS COUNTY						
Brewster-Bartle Drlg Co Inc	3	dsl	–	"Oilwell" 96	1500	16,000
	15	gas	–	Emsco	–	10,000
Columbia Drlg Co Bge	1	dsl	800	"Oilwell" 76	750	12,000
Continental Marine Expl Co	2	gas-btne	2120	Natl 110	1340	15,000
Bge	10	dsl	1245	"Oilwell" 96	1080	18,000
C J Foster Drlg Co Inc	8	gas-LPG	–	"Oilwell" 64-A	366	8,000
Holmes Drlg Co	7	gas-gaso	–	Beth MC-450	1000	11,000
Lubie Martin Drlg Co	1	gas	300	Brwstr N-4	400	6,000
Meadows & Walker Drlg Co	2	pwr	1950	Beth 1500	1578	16,000
Howard Parker Co	4	gas-btne	300	Crdwll D	750	9,500
CHEROKEE COUNTY						
Delta Drlg Co	40	gas-btne	325	Wlsn Rdr Gnt	690	8,000
Maxwell Herring Drlg Corp	8	gas	300	Wlsn Mogul	250	4,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Avail able to Drwwks	Rated Depth with 4½" Pipe
CLAY COUNTY						
Allied Expl Co	1	btne	350	Wlsn Roadmaster	–	8,000
Clyde Gibson Drlg Co	1	gas	600	Wlsn Gnt Rdair	700	7,000
Pan-Tex Drlg Co	1	gas	350	Brwstr N-45	400	6,500
COCHRAN COUNTY						
John Grappe Drlg Co	1	gas-btne	520	Beth	–	8,500
R Olsen	4	gas	1101	Wlsn Titan	1101	12,500
Sitton & Norton Drlg Co	1	btne	270	Wlsn Gnt	270	5,600
	2	btne	680	Natl 75	680	11,000
COKE COUNTY						
Dual Drlg Co	2	gas	400	Wlsn Gnt	400	7,500
Gardner Bros Drlg Co Inc	8	gas-btne	500	Natl 50	675	7,000
Roy Guffey Drlg Co	2	gas-btne	628	M-CSCO U-15	628	7,500
COLORADO COUNTY						
Dillard-Waltermire Inc	7	stm	800	Natl 23-9FM	1000	12,000
Triton Drlg Co Inc	8	gas	800	M-CSCO U-15	800	10,000/4"
CONEHO COUNTY						
West Central Drlg Co	9	gaso-btne	225	Spencer	145	3,000
COOKE COUNTY						
Alan Drlg Co	3	gas	275	Wlsn Mogul	145	3,500
Berry Drlg Co	1	dsl	350	Wlsn Giant	500	6,500
Brown & Martin Drlg Co	1	btne	230	Wlsn Giant	215	5,500
	2	btne	150	Wilson	105	1,500
Roy Guffey Drlg Co	5	gas-btne	430	M-CSCO U-34	260	5,500
Gene McCutchin Drlg Co	8	gas	550	Natl 50	550	8,000
Russell & Russell Drlg & Prod	1	gas-gaso-btne	275	Wlsn Giant	180	4,500
	2	–	400	Wlsn Tarcair	450	5,000
	3	–	350	Wlsn Mogul Trcair	350	5,000
Trachta Drlg Co	1	dsl	250	Wilson	185	3,000
CRANE COUNTY						
Delta Drlg Co	2	gas-btne	400	Natl 50	450	7,000
Eastland Drlg Co	4	gas	–	–	190	4,500
Gardner Bros Drlg Co Inc	5	gas-btne	500	Natl 75	675	9,000
	6	gas-btne	500	Natl 75	700	10,500
	12	gas-btne	750	Natl 100	1050	12,500
	20	gas-btne	275	Natl T-25	350	4,000
Guadalupe Drlg Co	1	gas-btne	700	Ideco M 1000	700	10,000
Helmerich & Payne Inc	42	gas	970	Natl 100	1000	13,000
Hewgley Drlg Co	5	dsl	–	Emsco J-750	975	11,000
Johnn Drlg Co	7	gas	325	Brwstr N-45	400	7,000
Layton & Newell Drlg Co	1	gas-btne	500	M-CSCO U-15	600	8,000
	2	gas-btne	450	Natl 75	780	12,000
McDaniel & Beecherl Drlg Co	10	gas-gaso	–	"Oilwell" 66	–	10,000
McQueen & Stout Drlg Co	12	LPG	225	Crdwll RL	185	4,500
	21	LPG	–	Emsco GA-500-53	–	–
Milestone Drlg Co	100	dsl	550	Ideco H-525	600	7,500
Parker Drlg Co	16	gas	–	Natl 100	1400	14,000
	53	gas	–	Natl 75	1000	11,000
B B Smith Inc	1	gas	600	Brwstr N-4	300	6,000/3-1/2"
	2	gas	600	M-CSCO U-15	450	7,000
	3	gas	400	Beth S-45	200	6,000/3-1/2"
Western Serv Drlg Co Inc	1	gas-btne	340	Natl 50	360	5,000
Wes-Tex Drlg Co	5	btne	550	Natl 50	550	7,500
Carl J Westlund Inc	7	gas-btne	650	Wlsn Roadair	–	8,500
CROCKETT COUNTY						
Frank Frawley Drlg Co	4	gas	–	M-CSCO U-40	850	10,000
John Grappe Drlg Co	3	gas-btne	1000	L C Moore	900	13,000
Johnn Drlg Co	5	gas	375	M-CSCO U-15	600	8,500
CULBERSON COUNTY						
McQueen & Stout Drlg Co	9	LPG	225	Crdwll RL	185	4,500
DAWSON COUNTY						
B B M Drlg Co	10	gas-btne	750	Emsco GA-500	700	7,000/3-1/2"
Dale Mount Drlg Inc	101	gas	850	Emsco	570	9,000
Parker Drlg Co	28	gas	–	Natl 50	700	9,000
DEAF SMITH COUNTY						
Norwood Drlg Co	3	gas-gaso	1050	Wlsn Titan	1050	12,500
DEWITT COUNTY						
Buzzini Drlg Co	7	gas-btne	1150	Wlsn Atlas	930	11,000
Dan L Clark Drlg Co	5	gas-btne	1025	Brwstr N-7	800	8,500
Field Drlg Co	1	dsl	1040	Natl 50-A	520	9,500
Harkins & Co	1	gas-gaso	555	M-CSCO U-15	555	9,500
Mangum Drlg Co	2	stm	1400	Emsco ECC	1400	16,000
Robinson-Wehmeyer Drlg Co	1	gas-btne	450	M-CSCO U-34	225	6,000
DIMMIT COUNTY						
Allen & Morris Drlg Co	7	dsl	500	Natl 75	900	10,000/5"
Sutton Drlg Co	1	dsl	–	–	225	3,500
DONLEY COUNTY						
Latexo Drlg Co Inc	1	gas-btne	370	Beth S-55 Twstr	370	7,500
DUVAL COUNTY						
Armstrong & Horn Drlg Co	1	dsl	450	Brwstr N-45	–	7,000
General Well Drlg Inc	1	pwr	450	Wilson Rdair	200	6,500/3-1/2"
J E Millier	3	dsl	800	Crdwll KM-250	400	8,500/3-1/2"
J & C Drlg Co	7	gas-btne	700	Emsco 500	600	9,000
EASTLAND COUNTY						
Maxwell Drlg Co	1	btne-gas	220	Brwstr N-4	220	4,500/3-1/2"
ECTOR COUNTY						
Beckman Inc	2	(wo) gas	185	Beth S-50	185	3,500
Big West Drlg Co	17	gas-btne	600	Wlsn Titan	900	13,000
Forest Blackstock Inc	1	gas	700	Emsco GB-350	700	8,000
Brantly Drlg Co Inc	2	gas	975	Emsco 800	1000	14,000
Capitan Drlg Co Inc	2	gas	450	Emsco G-450	450	7,000
Coraco Drlg Co	1	gas-gaso	500	Beth 650	650	12,500
	4	gas-gaso	650	Wlsn Spr Titan	900	15,000
Danforth Drlg Co	1	dsl	240	Ideco H-30	350	5,000
M J Delaney Co	30	gas-btne	500	Beth 1013	1200	15,000
Dillard-Waltermire Inc	12	gas	600	Wlsn Giant	800	8,000
	14	gas	600	Wlsn Giant	800	8,000
	16	gas	500	Natl 50	700	6,500
Durham Drlg Co Inc	2	gas	500	M-CSCO U-15	675	9,000
Eastland Drlg Co	1	gas	–	–	750	10,000
Lloyd R French Co	2	gas-btne	675	M-CSCO U-15	600	7,500
	3	gas-btne	650	Natl 50	600	7,500
	4	gas-btne	1200	Natl 75	900	12,500
Gardner Bros Drlg Co Inc	18	gas-btne	400	Natl 50	575	7,000
La Mance Drlg Co	3	btne	550	"Oilwell" 64	–	6,500
	4	btne	1050	Wlsn Titan	–	13,000
	5	btne	550	M-CSCO U-15	550	7,500
Layton & Newell Drlg Co	3	gas-btne	500	Natl 75	820	12,000
Lowe Drlg Co	1	gas	500	M-CSCO U-15	500	7,500
Norwood Drlg Co	1	gas-gaso	350	Wlsn Gnt Rdair	600	8,500
	6	gas-gaso	650	Wlsn Titan	900	12,000
Parker Drlg Co	26	gas-elec	–	Natl 130	2000	20,000
	32	gas	–	Natl 50	700	9,000
Schoenfeld-Hunter-Kitch Drlg	1	LPG-gas	–	Beth 650	1000	14,000
	4	LPG-gas	–	Natl 75	800	11,000
	6	LPG-gas	–	Beth 650	1000	14,000
	7	LPG-gas	–	Natl 110	1200	16,000
	10	LPG-gas	–	Beth Twister	300	6,500
Ray Smith Drlg Co	Nancy Ann II	gas-LPG	225	Ideco H-25	160	4,500/3-1/2"
	Sophie Jean	gas-LPG	625	Natl 50	625	8,000
Warton Drlg Co	2	gas	600	Natl 50	700	8,500
Western Serv Drlg Co Inc	7	gas-btne	600	Natl 50	700	7,000
FALLS COUNTY						
W W WiseDrlg Inc	2	dsl	550	Beth MC-450	550	9,000
FAYETTE COUNTY						
Hamman Oil & Ref Co	7	dsl	340	Brwstr N-75	600	11,000
FISHER COUNTY						
Roy Guffey Drlg Co	6	gas-btne	628	M-CSCO U-15	628	7,500
Johnn Drlg Co	9	gas	375	Brwstr N-45	400	7,000
Rhodes Drlg Co	11	gas	240	Emsco 350	360	5,000
FRANKLIN COUNTY						
Arrow Drlg Co	17	gas	1260	Emsco 1250	–	14,000
FREESTONE COUNTY						
M J Delaney Co	24	gas-btne	500	Beth M-58	600	9,500
	31	gas-btne	450	Wlsn Gnt Rdr	650	9,000
Delta Drlg Co	42	dsl	600	M-CSCO U-15	550	8,500
W W Wise Drlg Inc	1	gas	400	M-CSCO U-15	400	8,000
GAINES COUNTY						
Arrow Drlg Co	24	dsl	1200	Emsco 1000	–	14,000
Brantly Drlg Co Inc	4	gas	375	Beth S-55	480	6,500
Capitan Drlg Co Inc	1	gas	700	Emsco GC-500	700	10,000
Davey O'Brien Drlg Co Inc	3	gas-btne	700	Emsco GB-500	700	9,000
Dual Drlg Co	1	gas	600	Wlsn Giant	600	9,000
	4	950	600	Beth 810	1100	13,000
J E Jones Drlg Co	1	gas	500	"Oilwell" 66	630	8,000
Lowe Drlg Co	4	gas	750	Natl 75	750	10,000
Moran Oil Prod & Drlg Corp	2	gas	–	Natl 75	750	10,000
Dale Mount Drlg Inc	112	gas	1200	Emsco	1200	12,000
	114	gas	570	Crdwll	570	7,000
Norwood Drlg Co	2	gas-gaso	800	Wlsn Super Atlas	1000	12,500
Tri-Service Drlg Co	5	gas	825	"Oilwell" 76	825	10,000
Warton Drlg Co	4	gas	950	Emsco J-750	1000	12,000
Carl J Westlund Inc	6	gas-btne	975	Wlsn Titan	–	12,000
Wilbanks & Rutter Drlg Co	1	gas	1050	M-CSCO U-40	1050	10,000
GALVESTON COUNTY						
Bass Drlg Co	2	gas-gaso-btne	675	M-CSCO U-15	–	10,000
Continental Marine Expl Co	Bge 12	dsl	2000	Wlsn Titan 66	1875	22,800
C J Foster Drlg Co Inc	1	stm	–	National	1000	18,000
	3A	stm	–	Emsco EB-54-4	1000	18,000
Hunt Drlg Co Inc	7	stm	1200	Emsco ECA	1200	16,000
Howard Parker Co	1	gas-btne	600	Crdwll D	500	8,000
	6	gas-btne	400	Crdwll D	500	8,000
Penrod Drlg Co	4	dsl	1500	Natl 130	1500	20,000
	14	dsl	2200	Brwstr N-12-A	1800	18,500
The Power Rig Drlg Co Inc	Bge 7	dsl	1200	Emsco GB-800	–	15,000
GARZA COUNTY						
Calco Drlg Co	3	gas-btne	275	Emsco GB-250T	250	5,500
Drillers Inc	U-15	dsl	–	M-CSCO U-15	600	7,200
Dual Drlg Co	3	gas	600	Beth M-58	600	10,000
Empire Drlg Co	3	gas	500	Brwstr N-75	975	11,000
Texas R F O Inc	1	gas	325	Beth S-60	360	8,000
	3	dsl-gas	250	Emsco GA-250	290	5,000
Wes-Tex Drlg Co	9	btne	460	Emsco GA-500	570	9,000
GLASSCOCK COUNTY						
B B M Drlg Co	8	gas-btne	1050	Beth M-58	700	9,000
GOLIAD COUNTY						
Boyd & Durst Drlg Contr	2	gas-btne	650	Wlsn Giant	700	8,500
Fitzpatrick Drlg Co	3	dsl	775	Brwstr N-7	700	8,500
Harkins & Co	2	dsl	300	Wlsn Giant	300	6,500
	7	dsl	600	M-CSCO U-15	600	9,500
GRAY COUNTY						
King Edwards (Edwards Drlg Co)	11	btne	–	Wlkr-Nr Spdr	–	–
Latexo Drlg Co Inc	3	dsl	260	Brwstr N-4	260	5,000
Moran Bros Inc	12	gas	350	Crdwll "S"	250	4,000
Murphy & McKernan	1	dsl	390	M-CSCO U-15	375	7,500
GRAYSON COUNTY						
Jack Grace Drlg Co	12	gas-btne	625	Wlsn Atlas	1200	10,000
	20	gas-btne	370	Wlsn Giant	700	8,000
GREGG COUNTY						
Robert M Bass Drlg Contr	1	gas-LPG	500	Wlsn Roadair	800	10,000
Carter-Jones Drlg Co	6	gas-btne	–	–	350	6,800
	7	gas-btne	–	– 300	300	6,500
	11	gas-btne	–	–	280	6,500
	12	gas-btne	–	–	720	9,000
Delta Drlg Co	7	stm	750	Emsco UB-54	1200	12,000
	8	stm	750	Ideco Supr-Duty	1200	12,000
	15	gas-btne	530	M-CSCO U-15	600	8,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
HALE COUNTY						
Great Western Drlg Co	16	gas-gaso	775	M-CSCO U-914A	1260	15,000
HALL COUNTY						
Edgar Davis Drlg Co	12	gas-btne	650	Wlsn Giant	675	10,000
HANSFORD COUNTY						
Drlg & Expl Co of Del Inc	35	gas-gaso	1200	Emsco GB-800	900	12,000
Jack Grace Drlg Co	16	gas-btne	1020	Wlsn Titan	1200	12,500
Graham-Michaelis Drlg Co	4	dsl	500	M-CSCO U-15	500	7,000
Davey O'Brien Drlg Co Inc	2	gas-btne	840	Emsco GA-500	840	9,000
HARRIS COUNTY						
Big "6" Drlg Co	2	gas-btne	700	M-CSCO U-15	700	11,000
Burton Drlg Co	10	gas-gaso	–	–	–	6,000
Comet Drlg Co	3	stm	900	Ideco Jr Gnt	–	10,000
Mangum Drlg Co	3	gas-gaso	500	M-CSCO U-15	700	9,200
W P Taylor Drlg Co	2	gas	–	Natl	900	11,000
Taylor Expl Co Inc	1	btne	–	Failing	–	1,200
WLB Drlg Co	2	gas-gaso-btne	370	M-CSCO U-34	230	4,500
Chet Whaley Well Serv Co	1	gas-gaso-btne	225	Wlsn Giant	225	5,500/3-1/2"
	2	gas-gaso-btne	225	Wlsn Giant	275	5,500/3-1/2"
HARRISON COUNTY						
Barnwell Drlg Co Inc	7	dsl	800	Brwstr N-75	800	12,000
	34	dsl	800	M-CSCO U-34	500	7,000
HARTLEY COUNTY						
Baker & Taylor Drlg Co	8	gas-btne	750	Emsco G-500	750	9,000
HASKELL COUNTY						
T V Gorman Drlg Contr	2	dsl	300	Wlsn 38 Torcair	300	4,500
Hack Drlg Co	1	btne	–	M-CSCO U-15	412	8,500
Paine Drlg Co	5	btne	450	Wlsn Giant	450	7,000
Sojourner Drlg Corp	1	btne	218	M-CSCO U-15	555	7,500
	2	dsl	320	M-CSCO U-15	265	5,000
HEMPHILL COUNTY						
Baker & Taylor Drlg Co	1	dsl	800	M-CSCO U-15	800	8,500
HENDERSON COUNTY						
Halbert Drlg Co	2	gas-btne	285	Wlsn Roadair	445	6,500
HIDALGO COUNTY						
Dillard-Waltermire Inc	2	dsl	1800	Natl 125	2400	16,000
Fitzpatrick Drlg Co	1	stm	800	Ideco	1000	12,000
	2	gas	950	M-CSCO U-40	900	10,000
Hunt Drlg Co Inc	2	stm	1200	UBLS-54	1200	11,000
Milam Drlg Co	1	gas-btne	600	Emsco G-500	600	8,000
Turnbull & Zoch Drlg Co	8	gas-btne	850	M-CSCO U-15	850	9,500
Viking Drlg Co	3	gas-gaso	800	M-CSCO U-15	600	9,000
HOCKLEY COUNTY						
Drlg & Expl Co of Del Inc	14	gas-elec	1100	Natl 34-10	1000	17,000
Gardner Bros Drlg Co Inc	14	gas-btne	750	Natl 100	1050	12,500
Great Western Drlg Co	37	gas-gaso	700	M-CSCO U-40	1200	10,000
HOUSTON COUNTY						
Trant Drlg Co	1	dsl	500	M-CSCO U-15	1200	10,000/4"
HOWARD COUNTY						
Forest Blackstock Inc	3	gas	650	Emsco 500	650	9,000
Coroco Drlg Co	6	gas-gaso	400	"Oilwell" 66	500	9,000
O E Hall Drlg Co	5	gas	700	M-CSCO U-40	1210	12,000
J E Jones Drlg Co	2	gas	500	M-CSCO U-15	663	7,500
Lowe Drlg Co	5	gas	750	Natl 75	750	10,000
HUTCHINSON COUNTY						
Canadian River Drlg Co	1	dsl	300	M-CSCO U-34	300	5,000
	2	dsl	440	Wlsn Mogul	250	3,000
Graham-Michaelis Drlg Co	2	dsl	500	M-CSCO U-15	500	7,000
Latexo Drlg Co Inc	2	gas-btne	370	M-CSCO U-34	370	6,500
Rheay & Reynolds Drlg Co	8	gas	200	Wlsn Super	145	3,500
Service Drlg Co	1	dsl	250	M-CSCO U-34	180	4,000
	2	gas	220	M-CSCO U-34	225	4,500
Spradling Drlg Co	1	gas	300	M-CSCO U-34	300	4,500
JACK COUNTY						
Anderson Drlg Co	1	btne	225	Wlsn Mogul	–	4,000
Graytex Drlg Co	8	gas	325	Wlsn Mogul	300	4,000
Leatherwood Drlg Co	5	gas	220	Wlsn Gt Rdair	–	6,000
Paine Drlg Co	6	btne	500	Wlsn Giant	500	7,000
Louis Pitcock Drlg Co	7	gas-btne	225	Beth S-45	3250	4,000/3-1/2"
Ward Drlg Co	2	btne	300	Wlsn Giant	600	5,000
JACKSON COUNTY						
Bass Drlg Co	3	gas-gaso-btne	225	M-CSCO U-34	–	6,500
Davis & Bates Inc	1	dsl	549	Brwstr N-4	460	7,500
Hunt Drlg Co Inc	3	gas	965	Emsco GB-350	480	8,500
Mac Drlg Co	5	gas-gaso-btne	275	Beth S-45	450	7,500
	7	stm	500	Natl 34-26	5000	10,000
McKenzie Drlg Co	5	gas	440	Vic Skytop	400	7,000/3-1/2"
S D & S Drlg Co Inc	1	gas-btne	600	Ideco H-35	272	6,500
JASPER COUNTY						
Owen Drlg Co	8	dsl	1040	Natl 50	1040	10,000
Steen Drlg Co	3	btne-gas	700	Emsco J-750	1000	11,500
JEFFERSON COUNTY						
Columbia Drlg Co	6	dsl	800	Emsco GA-500	660	11,000
C J Foster Drlg Co Inc	2	gas-LPG	–	Brwstr N-75	834	11,000
Lake Drlg Co	1	gas-LPG	370	Wlsn Giant	–	5,800
	2	gas-LPG	180	Allis Chmrs	–	1,800
Meredith & Co	1	gas-gaso-btne	–	Emsco G-500	680	9,500
	3	gas-gaso-btne	–	"Oilwell" 96	1150	13,000
	4	gas-gaso-btne	–	Brwstr N-75	850	11,500
Howard Parker Co	3	gas-btne	500	Crdwll 0	900	11,000
JIM HOGG						
Well Drillers Inc	2	gas-gaso-btne	1821	Ideco 7-11 Spr	1446	16,000
JIM WELLS COUNTY						
Chiles Drlg Co	2	dsl	300	Ideco H-40	300	6,000
Falco Drlg Co	1	gas	700	Brwstr N-45	450	6,500
	2	gas	750	Wlsn Gnt	500	8,500
Prince Marine Drlg & Exp Co	5	dsl	500	Emsco GA-250-TS	300	7,000
Rhodes & Hicks Drlg Co	1	gas-btne	370	Frnks 137	200	5,500
Stice Drlg Co	1	btne-gas	496	M-CSCO U-15	–	7,500
Turnbull & Zoch Drlg Co	7	gas-btne	630	Ideco Rambler	630	10,000/3-1/2"
JOHNSON COUNTY						
Hamilton-Powell Drlg Co Inc	1	gas	225	Wlsn Mogul	–	4,500
JONES COUNTY						
Rhodes Drlg Co	1	dsl	480	Natl T-20	480	5,500
Woodson Prod Co	4	dsl	600	Mayhew 5000	270	5,500/4"
KARNES COUNTY						
Sutton Drlg Co	3	dsl	300	Brwstr N-4	350	6,500
Viking Drlg Co	5	gas	520	M-CSCO U-10	480	7,500
KENEDY COUNTY						
Hunt Drlg Co Inc	1	gas	1212	Brwstr N-7	732	10,000
KENT COUNTY						
Dual Drlg Co	5	gas	400	Emsco GA-500	400	7,000
Empire Drlg Co	2	gas	500	Brwstr N-7	750	9,500
John Grappe Drlg Co	2	gas-btne	720	Beth	–	13,000
West Central Drlg Co	8	gaso-btne	325	Wlsn Roadair	975	10,000
KNOX COUNTY						
Meredith Drlg Co	1	btne	225	Wlsn Super	145	3,500
Rheay & Reynolds Drlg Co	3	gas	400	M-CSCO U-15	1200	6,500
R Benton Ross Inc	1	dsl	225	Wilson	165	4,000
Sojourner Drlg Corp	3	dsl	550	M-CSCO U-15	520	7,500
LAMB COUNTY						
Hewgley Drlg Co	1	gas-btne	–	Emsco GA-500	650	8,500
LaSALLE COUNTY						
Longhorn Drlg Corp	4	gas-btne	450	M-CSCO U-15	675	9,000
Sutton Drlg Co	4	dsl	350	Brwstr N-4	875	10,500/2-7/8"
Taylor Expl Co Inc	3	gaso	–	Mayhew	75	1,000
	4	gaso	–	Mayhew	75	1,000
LEON COUNTY						
Robert M Bass Drlg Contr	6	stm	1200	Emsco U-BLS	1000	12,500
Bay City Drlg Co Inc	4	gas-btne	420	Brwstr N-45	420	8,000
Maxwell Herring Drlg Corp	4	gas	800	Wlsn Gnt Rdair	800	10,500
LIBERTY COUNTY						
Meadows & Walker Drlg Co	4	gas-btne	1455	"Oilwell" 76	1005	12,000
	5	gas-btne	2062	Beth	1988	16,000
Miller Bros & Bowling	2	gas-btne	800	Emsco G-450	–	8,500
Howard Parker Co	5	gas-btne	600	M-CSCO U-15	900	10,500
Steen Drlg Co	4	gas-btne	1350	Ideco 1050	1350	16,000
Timberland Expl Co	1	gas-btne	850	"Oilwell" 76	1050	10,500
LIMESTONE COUNTY						
Walters Drlg Co Inc	14	gas	–	Mayhew 1000	150	400/2-3/8"
LIPSCOMB COUNTY						
Baker & Taylor Drlg Co	5	gas-btne	1650	Natl 110	1650	15,000
Beckman Inc	12	(wo) gas	150	MW P-42	175	10,000/2-7/8"
Dillard-Waltermire Inc	15	gas	800	Wlsn Atlas	1200	11,000
Moran Bros Inc	5	gas	1400	"Oilwell" 860	1500	17,000
Rowan Drlg Co Inc	2	gas-btne	840	Natl 75	1120	11,000
Service Drlg Co	8	gas	300	M-CSCO U-34	300	6,700
Wagner & Wyant Drlg Co Inc	3	dsl	300	M-CSCO U-34	300	5,000
LIVE OAK COUNTY						
Allen & Morris Drlg Co	5	pwr	1100	"Oilwell" 76	780	12,000/5"
	8	stm	500	Emsco UBLS-54	1200	13,000/5"
Field Drlg Co	2	dsl	1000	M-CSCO U-15	750	10,000
General Well Drlg Inc	7	dsl	650	Crdwll	300	7,500
J & C Drlg Co	3	gas-btne	450	Natl 50	450	7,500
	5	dsl	800	Wlsn 54	800	12,000
Turnbull & Zoch Drlg Co	2	stm	1600	Ideco	1000	14,000
Viking Drlg Co	2	dsl	475	Natl 50-A	500	8,500
LOVING COUNTY						
Capitan Drlg Co Inc	3	gas	500	Natl 50	500	7,500
Leatherwood Drlg Co	2	gas	440	Natl T-32	–	7,000
	3	dsl	220	Natl T-20	–	6,000
	7	gas	650	Natl 50	–	10,000
McDaniel & Beechert Drlg Co	6	gas-gaso	–	Hou Prtble	–	5,000
	11	gas-gaso	–	Hou Prtble	–	5,000
LYNN COUNTY						
Ormand Bros Drlg Co	2	gas	550	Wlsn Giant	550	7,000
MARTIN COUNTY						
Coroco Drlg Co	2	gas-gaso	650	"Oilwell" 96	900	15,000
Davidson Drlg Co Inc	A	gas-btne	1000	Emsco J-1250	1000	14,000
MATAGORDA COUNTY						
Bay City Drlg Co Inc	3	gas-btne	850	"Oilwell" 66	800	10,800
Big "6" Drlg Co	5	gas-btne	820	Wlsn Gnt	550	10,500
Harry T Bryant Drlg Co Ltd	4	gas-btne	900	Natl 75	900	12,000
Columbia Drlg Co	5	dsl	600	M-CSCO U-15	450	8,500
Hamman Oil & Ref Co	6	dsl	250	Brwstr N-4	310	6,500
Holmes Drlg Co	1	gas-gaso	–	Beth ML-450	1000	11,000
Meadows & Walker Drlg Co	3	gas-btne	900	M-CSCO U-15	675	8,500
Neal Drlg Co	1	gas	850	Emsco G-500	560	10,000
Turnbull & Zoch Drlg Co	1	stm	1600	Emsco	1000	16,000
MAVERICK COUNTY						
Sutton Drlg Co	7	dsl	121	Alamo	225	5,000/2-7/8"
McCULLOCH COUNTY						
Law Drlg Co	2	btne	–	Wlsn	145	3,000
McMULLEN COUNTY						
General Well Drlg Inc	3	gas-btne	425	Beth	183	5,500/3-1/2"
Harkins & Co	4	gas-gaso	700	Wlsn Giant	700	9,500
MIDLAND COUNTY						
B B M Drlg Co	1	gas-btne	950	Emsco GB-800	1050	14,000/4"
	4	gas-btne	550	Natl 50	600	8,500/3-1/2"
Forest Blackstock Inc	4	gas	700	Emsco GB-350	700	8,000

900 to 1400
HORSEPOWER

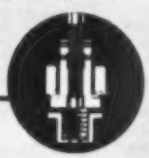
Big Drawworks with Small Rig Simplicity

Rated at 900 to 1400 net input horsepower, the Mid-Continent U-914-C Drawworks offers the drilling industry all the desirable features of a large rig, while retaining the flexibility and simplicity of operation of smaller units. The U-914-C is designed as a single package unit containing hoisting drum, transmission, rotary drive, and auxiliary brake on a single skid. Rugged in construction and smooth in operation, this unit provides dependable, economical and trouble-free service to meet present day drilling practices. For complete information, contact your local Mid-Continent representative.

D-914-U

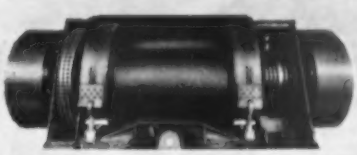
SELF-EQUALIZING 52" x 10" BRAKES

Double adjustment, individually equalized bands have spring loaded spherical dead-end equalizer seats which eliminate bending of the dead-end pins.



EXTRA LARGE BALANCED DRUM FAWICK VC CLUTCHES

A 29" diameter by 53¼" long drum provides three wrap spooling when hoisting 90-foot stands with a 10 line reeving system using 1¼" wire line and LeBus grooving. Hi- and lo-drum clutches are identical 38VC1200 Fawick Ventorque. A splined clutch is provided on the lo-drum side for emergency use.



ALL BEARINGS GREASE LUBRICATED UNITIZED CONTROLS

MID-CONTINENT SUPPLY CO.

MID-CONTINENT BUILDING • FORT WORTH, TEXAS

Export Division: 45 Rockefeller Plaza, New York 20, N. Y. Cable: MIDCUMPORT NYK

THE WORLD'S LARGEST INDEPENDENT OIL FIELD SUPPLY COMPANY

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Avail able to Drwks	Rated Depth with 4½" Pipe
Choya Drlg Co Inc	1	gas	750	Emsco GB-500	780	9,500
	3	gas-btne	900	Beth MC-650	900	12,000
	4	gas-btne	1400	Emsco J-1400	1400	15,000
	5	gas-btne	700	Emsco GB-350	660	8,500
Sam E Crump Drlg Co	1	gas	–	M-CSCO U-15	650	8,500
Marcum Drlg Co	2	gas-btne	500	"Oilwell" 760	1000	12,000
Parker Drlg Co	39	gas	–	Natl 100	1400	14,000
Rowan Drlg Co Inc	7	gas-btne	1260	Natl 100	1680	14,000
MILAM COUNTY						
Bay City Drlg Co Inc	1	gas-btne	430	"Oilwell" 52-T	430	7,000
MONTAGUE COUNTY						
Paine Drlg Co	7	dsl	450	Wlsn Giant	450	7,000
Louis Pitcock Drlg Co	1	gas-btne	225	Beth S-55	600	7,500
MONTGOMERY COUNTY						
Brewster-Bartle Drlg Co Inc	4	gas	–	"Oilwell" 76	–	11,000
Harry T Bryant Drlg Co Ltd	5	gas-btne	700	Beth M-58	800	11,000
Meadows & Walker Drlg Co	1	gas-btne	875	"Oilwell" 66	828	10,500
Mobile Drlg & Well Serv Co Inc	1	gas-btne	490	Ideco HD-35	450	7,000/3-1/2"
MOORE COUNTY						
Kerr-McGee Oil Ind Inc	34	dsl	300	Frnks LTX-5000	300	5,000
Davey O'Brien Drlg Co Inc	5	gas-btne	560	Wlsn Gnt	560	8,000
Service Drlg Co	10	gas	350	M-CSCO U-34	180	5,500
MOTLEY COUNTY						
Norwood Drlg Co	8	gas-gaso	300	Wlsn	175	4,000
NEWTON COUNTY						
Timberland Expl Co	3	gas-btne	800	M-CSCO U-15	700	9,000
NOLAN COUNTY						
Dixon Drlg Co	3	gas	500	Natl 50	520	7,500
Empire Drlg Co	9	gas	500	M-CSCO U-15	675	8,500
General Geophysical Co	32	btne	–	–	500	7,500
Hondo Drlg Co	6	gas	450	M-CSCO U-15	450	7,000
E W Moran Drlg Co	1	gas	500	M-CSCO U-15	560	7,500
Thomas & Billups Drlg Co	1	btne	450	Emsco 300	450	6,000
NUECES COUNTY						
Appell Petroleum Corp	2	dsl	685	Frnks SG-101	400	8,500
	4	gas-gaso	630	Crdwll	370	7,000/3-1/2"
Chiles Drlg Co	3	gas	400	Ideco H-40-D	460	7,500
	4	gas	1000	Emsco GC-500	550	9,500
Frio Drlg Inc	2	dsl	400	M-CSCO U-15	400	6,500
Miller Bros & Bowling	1	gas-btne	495	Emsco G-300	–	5,500
OCHILTREE COUNTY						
Arrow Drlg Co	9	gas	560	Emsco 500	–	8,000
	10	gas	560	Emsco 500	–	8,000
Baker & Taylor Drlg Co	3	dsl	800	M-CSCO U-15	800	8,500
	4	gas-btne	750	Emsco G-500	750	9,500
	7	gas-btne	1000	Natl 55	1000	10,500
Dillard-Waltermire Inc	11	gas	600	Wlsn Giant	800	8,000
Foree Drlg Co	4	gas-btne	325	Emsco GA-500	500	7,500
Lynn Drlg Co	2	gas-btne	425	Natl 75	700	10,000
	4	gas-btne	450	Natl 50	675	8,000
Midwestern Drillers Inc	8	dsl	370	M-CSCO U-15	750	8,500
Rowan Drlg Co Inc	10	gas-btne	1020	Beth 450	766	9,000
Wagner & Wyant Drlg Co Inc	4	gas-btne	500	M-CSCO U-15	700	9,000
OLDHAM COUNTY						
Jack Grace Drlg Co	8	gas-btne	625	Wlsn Atlas	1200	10,000
ORANGE COUNTY						
Wheless Drlg Co	Bge 7	dsl	2000	Natl 130	1900	18,000
PALO PINTO COUNTY						
E & H Drlg Co	2	gas	275	M-CSCO U-34	225	4,500
Hondo Drlg Co	2	gas	450	M-CSCO U-15	450	5,500
PANOLA COUNTY						
Barnwell Drlg Co Inc	4	gas	800	Brwstr N-7	800	10,000
Carter-Jones Drlg Co	8	gas-btne	–	–	500	7,500
D Thomason Drlg Co Inc	1	pwr	–	Brwstr	–	15,000
PARKER COUNTY						
Alan Drlg Co	1	gas	550	Wlsn Giant	850	8,000
Jim Fish Drlg Co	1	gas	225	Wilson	140	4,500
C J Simpson Drlg Co	4	gas-btne	–	Natl T-20	275	5,000
PECOS COUNTY						
Alan Drlg Co	2	gas	350	Wlsn Mogul	185	4,000
Brantly Drlg Co Inc	1	gas	365	Emsco 500	500	9,000
Delta Drlg Co	4	gas-btne	800	Natl 100	800	12,000
	6	gas-btne	800	Emsco J-750	750	9,500
	36	gas-btne	900	Wlsn Titan	900	15,000
Durham Drlg Co Inc	1	gas	500	M-CSCO U-15	660	8,500
	4	gas	1250	Ideco 7-11	1450	15,000
Great Western Drlg Co	44	dsl-elec	1400	M-CSCO U-1220	3000	25,000
Helmerich & Payne Inc	37	gas	1200	"Oilwell" 96	1450	15,000
La Mance Drlg Co	1	btne	350	Frnks 5000	–	5,000
Norwood Drlg Co	4	gas-gaso	500	Wlsn Gnt Rdair	600	9,500
	7	gas-gaso	650	Wlsn	700	9,500
Parker Drlg Co	44	gas	–	Natl 125	1400	15,000
Penrod Drlg Co	32	dsl	1500	Brwstr N-12	1675	18,000
Rowan Drlg Co Inc	29	gas-btne	1200	Natl 1000	1480	14,000
Schoenfeld-Hunter-Kitch Drlg	9	LPG-gas	–	Natl 75	900	11,000
Carl J Westlund Inc	5	gas-btne	650	Natl 50	–	8,500
REAGAN COUNTY						
Helmerich & Payne Inc	43	gas	900	"Oilwell" 76	1100	11,000
Marcum Drlg Co	1	gas-btne	325	M-CSCO U-15	675	8,000
	4	gas-btne	325	Brwstr 55-W	700	7,500
Pool & Gerlich Drlg	D-1	gas	260	M-CSCO U-34	300	5,000
Robinson Bros Drlg Co	1	gas	800	Brwstr N-75	800	10,000
Tri-Service Drlg Co	2	gas	675	"Oilwell" 66	675	8,500
	8	gas	900	"Oilwell" 76	900	10,000
REEVES COUNTY						
Beard & Walker Drlg Co	1	btne	145	Crdwll	145	3,000
Ellis	4	dsl	300	M-CSCO U-34	300	5,000
Gardner Bros Drlg Co Inc	16	gas-btne	1000	Natl 125	1400	15,000
Leatherwood Drlg Co	4	gas	450	Crdwll	450	6,000
REFUGIO COUNTY						
Field Drlg Co	4	dsl	520	Beth Breeze	260	6,500
Holmes Drlg Co	6	gas-gaso	–	Beth MC-450	700	10,000
J & C Drlg Co	2	stm	600	Emsco H-46	700	9,000
	6	gas-btne	450	Natl 50	450	7,500
Viking Drlg Co	1	dsl	475	Natl 50	500	8,500
ROBERTS COUNTY						
Arrow Drlg Co	1	gas	860	Ideco 1000	–	11,500
Moran Bros Inc	11	gas	700	Wlsn Gnt	750	10,000
Parker Drlg Co	57	gas	–	Natl FE 23-X10	1800	18,000
RUNNELS COUNTY						
Frank Caraway Drlg Co	1	btne-gas	225	Beth S-50	–	5,000
Roy Guffey Drlg Co	3	gas-btne	430	M-CSCO U-34	260	5,500
Herb Expl Co	3	btne	–	Failing 1500	–	2,000/2-3/8"
Petroleum Drlg Co	3	gas	400	Natl 50	650	8,000
Sojourner Drlg Corp	5	btne	225	Natl T-8-S	145	3,250
RUSK COUNTY						
Barnwell Drlg Co Inc	11	dsl	1200	Brwstr N-85	1200	13,000
Pyburn Drlg Co	1	dsl	500	Ideco M-750	750	9,000
South States Drlg Co	4	dsl	275	Emsco GA-350	480	7,000/4"
D Thomason Drlg Co Inc	2	pwr	–	Natl	–	10,000
SAN PATRICIO COUNTY						
Allen & Morris Drlg Co	2	stm	500	Alco BIW 12	1200	14,000/5"
Dan L Clark Drlg Co	2	gas-btne	1000	Emsco GC-500	500	7,500
Frio Drlg Inc	3	gas-btne	800	Brwstr N-55	800	10,500
Harkins & Co	6	gas-gaso	675	M-CSCO U-15	675	9,500
Viking Drlg Co	4	gas-gaso	980	Ideco M-10,000	750	12,000
SCHLEICHER COUNTY						
Davidson Drlg Co Inc	D	btne	315	Wlsn Mogul	600	7,500
Great Western Drlg Co	5	gas-gaso	500	M-CSCO U-15	770	7,500
Henson Drlg Co	2	btne	540	M-CSCO U-15	540	7,500
Petroleum Drlg Co	2	dsl	400	Wlsn Gnt	600	8,000
SCURRY COUNTY						
Dave Harlin Drlg Co	1	btne	–	Beth	–	12,000/2-7/8"
Marcum Drlg Co	3	gas-btne	500	Emsco GA-500	850	9,000
Pico Drlg Co	2	gas-btne	475	Brwstr N-7	475	8,500
	3	gas-btne	610	M-CSCO U-15	470	8,500
SHACKELFORD COUNTY						
Gore Drlg Co	1	dsl	640	Shovel Spl	–	7,500
SHELBY COUNTY						
Carter-Jones Drlg Co	10	gas-btne	–	–	500	7,000
SHERMAN COUNTY						
Drlg & Expl Co of Del Inc	24	gas	225	Wgnr Mthse	400	5,000
Wagner & Wyant Drlg Co Inc	2	dsl	500	M-CSCO U-15	675	8,000
SMITH COUNTY						
Robert M Bass Drlg Contr	3	gas-LPG	400	Wlsn Gnt Roadair	600	8,500
	4	gas-LPG	350	Brwstr N-45	350	7,000
B G Byars Power Drlg Co	1	gas-btne	1170	Beth MC-450	775	11,000
	2	gas-btne	1145	Emsco GA-500	750	10,500
	3	dsl	400	Emsco G-300	300	5,500
Delta Drlg Co	22	gas-btne	530	M-CSCO U-15	600	8,000
Maxwell Herring Drlg Corp	3	gas	700	Wlsn Gnt Rdair	700	9,500
Trant Drlg Co	3	stm	–	–	–	15,000
STARR COUNTY						
Holmes Drlg Co	3	gas-gaso	–	Natl 110	1500	16,000
Turnbull & Zoch Drlg Co	3	gas-btne	1125	Wlsn Titan	1125	16,000
STEPHENS COUNTY						
Edgar Davis Drlg Co	11	gas-btne	325	M-CSCO U-15	600	7,500
E & H Drlg Co	1	gas	550	M-CSCO U-15	550	7,500
King Edwards (Edwards Drlg Co)	3	gas-gaso	600	M-CSCO U-15	600	9,000
H O Grace Drlg Co	3	btne	–	–	–	6,000
Oney Drlg Co	5	gas	250	Crdwll S	200	4,000
R-G Drlg Co Inc	1	gas-gaso	–	Wilson	650	6,500
Taylor Expl Co Inc	6	btne	–	Failing	–	1,200
	7	btne	–	Mayhew	–	1,200
Wright Clark & Senkel Inc	11	gas-btne	450	Wlsn Giant	450	7,500
	18	gas-btne	450	Wlsn Gnt Rdmstr	450	7,500
STERLING COUNTY						
Rheay & Reynolds Drlg Co	6	gas	300	Natl 50	750	7,000
STONEWALL COUNTY						
Dixon Drlg Co	4	dsl-gas	200	Natl T-12	200	4,000
	5	gas	320	M-CSCO U-15	600	8,000
Fryer & Hanson Drlg Co	10	gas-btne	225	M-CSCO U-34	275	4,500
W B Omohundro	8	btne	700	Wlsn Roadair	–	8,000
	10	btne	300	Brwstr N-3	–	4,500/3-1/2"
Varner-Neill Drlg Co	1	gas	500	Wlsn Giant	450	6,000
SUTTON COUNTY						
Great Western Drlg Co	34	dsl	495	M-CSCO U-40	1200	10,000
TAYLOR COUNTY						
Black Drlg Co	1	dsl	275	Frnks	250	4,000/3-1/2"
Edgar Davis Drlg Co	14	gas-btne	225	Spencer-Harris	180	4,000
Dixon Drlg Co	1	dsl-gas	260	Natl T-20	260	5,000
Gore Drlg Co	2	dsl	320	Beth	–	5,000
Hack Drlg Co	2	btne	–	Crdwll S	161	4,500
	3	btne	–	M-CSCO U-15	412	8,500
Henson Drlg Co	1	btne	825	M-CSCO U-15	825	7,500
	3	btne	825	M-CSCO U-15	825	7,500
	5	btne	810	M-CSCO U-15	810	7,500
Herb Expl Co	2	btne	–	Failing 1500	–	1,750/2-3/8"
Low Drlg Co	1	btne	–	Emsco	290	7,000
Norman Drlg Corp	2	dsl	330	M-CSCO U-10	350	5,000
Sojourner Drlg Corp	4	btne	225	M-CSCO U-34	225	4,500
West Central Drlg Co	7	gase-btne	225	Wlsn Giant	250	5,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Wes-Tex Drlg Co	1	btne	250	M-CSCO U-10	650	6,000
	2	btne	220	Brwstr N-4	400	5,500
	3	btne	225	Crdwll 53	420	5,500
	7	btne	200	Crdwll D	225	3,000
TERRELL COUNTY						
Great Western Drlg Co	18	dsl	955	M-CSCO U-914A	1800	15,000
Helmerich & Payne Inc	48	gas-btne	1200	Natl 110	1300	15,000
Rowan Drlg Co Inc	28	gas-btne	1300	Natl 125	1530	15,000
Western Serv Drlg Co Inc	2	gas-btne	600	Natl 50-A	700	8,000
TERRY COUNTY						
Empire Drlg Co	9	dsl	325	Wlsn Giant	550	7,500
Great Western Drlg Co	38	gas-gaso	320	M-CSCO U-15	675	7,500
Johnn Drlg Co	6	gas	850	Brwstr N-95	1300	14,000
Midland Drlg Co	1	gas-btne	600	M-CSCO U-15	600	8,000
THROCKMORTON COUNTY						
Gore Drlg Co	3	gas	254	Joy 200-A	–	2,500/2-7/8"
E W Moran Drlg Co	5	gas	370	Natl 50	650	7,500
Noel Pautsky	1	dsl	300	Wlsn Mogul	300	5,500
R-G Drlg Co Inc	2	gas-gaso	–	Wlsn	650	8,000
	3	gas-gaso	–	Wilson	450	6,500
	5	gas-gaso	–	Wilson	650	8,000
Dwight M Ross Drlg Co	6	gas	750	Wlsn Atlas	750	7,000
TITUS COUNTY						
W B Hinton	1	stm	750	Alco BIW-11	–	10,000
TOM GREEN COUNTY						
Roy Guffey Drlg Co	4	gas-btne	628	M-CSCO U-15	628	7,500
Pool & Gerlich Drlg	D-3	gas	350	Emsco G-250	300	6,000
TYLER COUNTY						
Harry T Bryant Drlg Co Ltd	2	gas-btne	700	–	600	8,000
	3	gas-btne	700	TIW 5	600	8,000
Timberland Expl Co	2	gas-btne	1100	"Oilwell" 76	1200	12,500
UPTON COUNTY						
Empire Drlg Co	7	gas	600	Wlsn Titan	975	13,500
Helmerich & Payne Inc	39	gas	1100	"Oilwell" 96	1300	14,000
King-Phillips Inc	1	gas-gaso	695	Natl 50	–	7,500
Llano Drlg Co	3	gas	–	"Oilwell" 96	975	14,000
Lowe Drlg Co	2	gas	750	Wilson	750	10,000
Penrod Drlg Co	1	gas-btne	1300	Brwstr N-12	1750	17,500
VAL VERDE COUNTY						
Hewgley Drlg Co	2	gas-btne	–	Ideco	1400	14,000
Rowan Drlg Co Inc	25	gas-btne	1260	Natl 100	1680	14,000
VICTORIA COUNTY						
Big "6" Drlg Co	3	gas-btne	500	Crdwll Trg	500	7,500
Glenn Drlg Co	3	gas	145	Crdwll S	145	4,000
Harkins & Co	3	gas-gaso	850	M-CSCO U-15	850	10,000
WARD COUNTY						
Robert M Bass Drlg Contr	2	gas-LPG	300	Wlsn Giant	300	5,500
Dillard-Waltermire Inc	13	gas	800	Wlsn Titan	1200	12,000
Gardner Bros Drlg Co Inc	11	gas-btne	750	Natl 100	1050	12,500
King-Phillips Inc	3	dsl	622	Ideco H-40D	–	5,500/4"
Leatherwood Drlg Co	1	gas	600	Ideco 750	–	10,000
Dale Mount Drlg Inc	115	gas	1200	Emsco	1200	12,000
Pico Drlg Co	1	dsl	368	Brwstr N-4	216	5,000
	5	gas-btne	356	"Oilwell" A-64-3	356	6,000
Rowan Drlg Co Inc	9	gas-btne	900	Natl 75	1110	11,000
Texas Drlg Co	1	gas	300	Natl T-20	300	5,000/3-1/2"
	2	dsl	427	Brwstr N-4	216	4,500
Western Serv Drlg Co Inc	13	gas-btne	550	Beth S-45-E	350	5,000
WEBB COUNTY						
Bay City Drlg Co Inc	5	gas-btne	750	Emsco G-500	700	9,000
Chiles Drlg Co	1	gas	600	Brwstr N-7	600	8,500
Longhorn Drlg Corp	5	gas-btne	450	M-CSCO U-15	675	9,000
	6	gas-btne	500	"Oilwell" 76	1185	14,000
WHARTON COUNTY						
W P Taylor Drlg Co	3	gas	–	Natl	900	11,000
WHEELER COUNTY						
Service Drlg Co	6	dsl	300	M-CSCO U-34	225	6,000
WICHITA COUNTY						
T V Gorman Drlg Contr	1	dsl	200	Wichtex R-3	200	3,000
Gray Drlg Co	1	gas-gaso	220	Wlsn Gnt Roadair	450	5,500
Harvey Drlg Co	3	gas-btne	350	Wlsn Mogul	400	5,000
	5	gas-btne	750	Wlsn Giant	800	8,500
	6	gas-btne	500	Wlsn Giant	500	7,500
Hull Oil Co	1	btne	140	Wlkr-Nr R-2	–	2,150
Meredith Drlg Co	2	btne	500	Wlsn Giant	225	7,500
W B Omahundro	9	btne	550	Wlsn Roadair	–	6,500
WILBARGER COUNTY						
Graytex Drlg Co	2	gas	325	Natl T-12	325	4,500
B M Hester	1	btne	325	Natl T-20	200	6,000
E W Moran Drlg Co	3	dsl	285	Wlsn Giant	650	7,500
	6	gas	225	Wlsn Mogul	160	4,500
W B Omahundro	4	btne	450	Wlsn Atlas	–	6,000
WILLIAMSON COUNTY						
Pegg Bros Drlg Co	3	gas-btne	90	–	90	1,500/2-7/8"
WINKLER COUNTY						
B B M Drlg Co	2	gas-btne	1100	Emsco GB-800	1050	14,000/4"
Beckman Inc	1	(wo) gas	185	M-CSCO U-15	350	6,000
Calco Drlg Co	5	dsl	325	Beth S-45-E	300	5,500
	6	gas-btne	600	M-CSCO U-15	500	7,500
Camden Drlg Co Bge	2	dsl	600	Natl T-32	300	7,500
Frontier Drlg & Prod Co	8	dsl	300	Brwstr N-4	300	5,000
Johnn Drlg Co	3	gas	650	Wlsn Atlas	900	10,000
Leatherwood Drlg Co	6	gas	220	Wlsn Giant	–	4,500
Llano Drlg Co	2	gas	–	Natl 100	975	14,000
McQueen & Stout Drlg Co	10	LPG	225	Crdwll RL	185	4,500
Dale Mount Drlg Inc	111	gas	1200	Emsco	1200	14,000
Ormand Drlg Co Inc	1	gas	550	Wlsn Giant	550	7,000
Parker Drlg Co	33	gas	–	Natl 75	1000	11,000
Western Serv Drlg Co Inc	12	dsl	250	Natl T-20	520	4,000
WISE COUNTY						
Frank Frawley Drlg Co	5	gas	–	M-CSCO U-15	675	8,500
H O Grace Drlg Co	4	btne	–	–	–	7,500
Jack Grace Drlg Co	5	gas-btne	500	Wlsn Atlas	700	10,000
	19	gas-btne	225	Wlsn Giant	350	5,000
John W Harris Drlg Co	1	gas	500	Hou Prtble	450	6,500
	2	gas	500	Emsco GC-500	500	8,000
John Haseman Inc	1	gas-btne	350	Ideco H-35D	300	6,000
	2	gas-btne	150	Wlsn Super	150	3,500
	4	gas-btne	150	Crdwll K-200	150	3,500
Holliman Drlg Co	3	gas	255	M-CSCO U-15	600	7,500
Gene McCutchin Drlg Co	5	gas	275	Wlsn Giant	275	6,500
E W Moran Drlg Co	4	gas	300	M-CSCO U-15	650	7,500
Trio Drlg Co	1	gas	520	Wlsn Giant	–	8,000
	2	gas	520	Natl 50	–	6,500
	3	gas	450	Wlsn Giant	–	6,500
	4	gas	450	Natl 50	–	6,500
Walters Drlg Co Inc	12	dsl	–	Mayhew 1000	300	400/2-3/8"
WOOD COUNTY						
B-M Drlg Co Inc	2	gas	685	Emsco GB-350	500	8,000
M J Delaney Co	21	gas-btne	500	Wlsn Titan	650	9,500
Halbert Drlg Co	1	gas-gtne	255	Wlsn Torcair	285	5,500
	3	gas-btne	710	M-CSCO U-15	710	9,500
YOAKUM COUNTY						
Brantly Drlg Co Inc	5	gas	375	Emsco 250	250	4,000
Eastland Drlg Co	2	gas	–	–	540	7,500
Empire Drlg Co	5	gas	325	M-CSCO U-15	550	8,000
Lloyd R French Co	1	gas-btne	765	Natl 50	600	9,000
Great Western Drlg Co	12	gas-gaso	1350	M-CSCO U-20	1755	16,000
Moran Oil Prod & Drlg Corp	3	gas	950	M-CSCO U-15	800	8,500
Fred Pool Drlg Co	1	gas	580	M-CSCO U-15	600	7,500
Tri-Service Drlg Co	6	gas	1350	"Oilwell" 96	1350	16,000
Wes-Tex Drlg Co	6	btne	500	M-CSCO U-15	640	8,500
YOUNG COUNTY						
Jess P Cross Drlg Contr	1	gas-btne	250	Wlsn Gnt	230	4,500/3-1/2"
R W Darden Drlg Co	1	gas	145	Wichtex R-3	140	3,000
King Edwards (Edwards Drlg Co)	2	gas-gaso	600	M-CSCO U-15	600	9,000
H O Grace Drlg Co	1	btne	–	–	–	6,000
Hamilton Investment Co	1	btne	350	Wlsn Gnt	225	6,500
J W Hastings Drlg Co	4	gas-btne	330	Wlsn Torcair	220	5,000
	5	gas-btne	864	Wlsn Gnt Roadair	864	8,200
Lin-Mour Drlg Co	1	gas	315	Wlsn Mogul	400	4,600
Turner & West	1	gas	300	Natl T-32	300	5,500
ZAPATA COUNTY						
Allen & Morris Drlg Co	4	gas	450	Natl 50	450	8,500/5"
Hunt Drlg Co Inc	4	gas	846	Emsco GB-250	306	7,000
UTAH						
CARBON COUNTY						
Mountain States Drlg Co Inc	11	gas-dsl	1000	Natl 80-B	–	12,500
DUCHESNE COUNTY						
Miracle & Wooster Drlg Co	–	gas	850	"Oilwell" 76	700	10,000
Mountain States Drlg Co Inc	4	gas-dsl	600	Emsco GB-500	–	9,000
Pioneer Drlg Co Inc	5	dsl	850	Emsco J-750	1000	12,000
EMERY COUNTY						
Great Western Drlg Co	23	dsl	500	M-CSCO U-15	800	9,000
Llano Drlg Co	4	gas	–	Natl 75	1050	12,000
GARFIELD COUNTY						
Pioneer Drlg Co Inc	3	dsl	800	Emsco GA-500	700	9,000
SAN JUAN COUNTY						
Arapahoe Drlg Co	2	gas-btne	300	Natl T-32	320	6,000
	4	gas-btne	375	Natl 50-A	680	8,000
Exploration Drlg Co	16	gas	725	Natl 75	600	9,000
Great Western Drlg Co	14	dsl	320	M-CSCO U-15	800	9,000
	30	dsl	500	M-CSCO U-15	750	7,500
	31	gas-gaso	307	M-CSCO U-15	840	9,000
	36	gas-gaso	320	M-CSCO U-15	675	7,500
	42	dsl	500	Emsco G-500	800	9,000
Hondo Drlg Co	5	gas	675	Natl 55	675	11,000
Kerr-McGee Oil Ind Inc	1	gas	825	M-CSCO U-15	832	10,000
Moran Bros Inc	3	gas	550	Emsco GB-350-52	550	8,000
	8	gas	900	Wlsn Gnt	750	9,500
	9	gas	700	"Oilwell" 66	750	9,500
	10	gas	600	Emsco GA-350	550	8,000
Mountain States Drlg Co Inc	6	dsl	600	Natl 50	–	7,500
Rhodes Drlg Co	5	gas	450	M-CSCO U-15	675	9,000
R W Rine Drlg Co	2	dsl	520	Brwstr N-7	600	8,500
	6	dsl	520	Brwstr N-75	750	12,000
Rutledge Drlg Co	5	gas-btne	632	Natl 50	620	8,000
UINTAH COUNTY						
Brinkerhoff Drlg Co	21	dsl	650	Emsco GC-500	800	10,000
Camay Drlg Co Rocky Mt Div	1	gas	775	M-CSCO U-15	600	8,500
Carpenter-Trant Drlg Co	8	btne	800	Wlsn Spr Gnt	1320	12,000
Exploration Drlg Co	11	gas	800	Beth S-60	480	8,000
Kerr-McGee Oil Ind Inc	4	gas	900	Natl 75	832	11,500
	23	gas	650	Natl 50	556	9,000
Miracle & Wooster Drlg Co	–	gas	850	M-CSCO U-15	500	7,500
WAYNE COUNTY						
Camay Drlg Co Rocky Mt Div	3	dsl	560	Natl 50-A	450	8,500
WEST VIRGINIA						
FAYETTE COUNTY						
Lohmann-Johnson Oil Co Inc	2	gas	500	"Oilwell" 76	750	10,000
JACKSON COUNTY						
Glenn Gillespie & Sons	2	gas-dsl	360	Wlsn Mogul	280	6,000
KANAWHA COUNTY						
Delta Drlg Co	33	gas-btne	624	Natl 50-A	350	7,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Avail-able to Drwwks	Rated Depth with 4½" Pipe
POCAHONTAS COUNTY						
Union Rotary Drls (Can) Ltd	6	dsl	600	Natl 50	600	8,500
RANDOLPH COUNTY						
S W Jack Drlg Co	2	dsl	800	M-CSCO U-15	800	8,500
	4	gas	1000	M-CSCO U-15	1000	10,000
RITCHIE COUNTY						
Delta Drlg Co	29	dsl	750	Emsco J-750	750	12,000
WYOMING						
BIG HORN COUNTY						
Roden & McRae Drlg Corp	2	dsl	265	Emsco GA-300	270	4,500
	5	gas	360	Emsco GA-250T	425	6,500
	6	dsl	275	Frnks Rocket TD44	275	2,000
CAMPBELL COUNTY						
Olen Oil Corp	3	dsl	500	Natl T-20	280	5,000
A L Schlaikjer	1	gas	832	Wisn Gnt Rdair	832	9,000
True Drlg Co	10	gas-LPG	1000	M-CSCO U-15	675	8,500
CARBON COUNTY						
Kerr-McGee Oil Ind Inc	31	gas	1000	Natl 100	1680	15,000
Roden & McRae Drlg Corp	1	dsl	625	Emsco GA-350	570	7,000
CROOK COUNTY						
A O Bullock Drlg Co	1	gas	225	Wichtex R5	–	3,500
Delta Drlg Co	23	dsl	520	Emsco GA-500	500	8,000
Lohmann-Johnson Drlg Co Inc	4	dsl	300	M-CSCO U-15	440	5,500
True Drlg Co	3	gas-LPG	800	Natl 50	500	7,500
	11	gas-LPG	1150	Natl 75	750	9,500
FREMONT COUNTY						
Delta Drlg Co	43	dsl	400	M-CSCO U-10	450	6,000
Gabe McCall Drlg Co	2	dsl	600	Emsco GB-250	360	6,500
Nye & Snell Drlg Co	3	gas	600	Wisn Atlas	800	11,000
Teton Drlg Co Ltd	1	dsl	520	Emsco GB-250	360	6,500
True Drlg Co	4	gas-LPG	650	Emsco 250	400	6,000
GOSHEN COUNTY						
True Drlg Co	7	dsl	350	Failing 66	185	3,000
HOT SPRINGS COUNTY						
Arrow Drlg Co	14	gas	600	Wisn	–	8,000
J D Sprecher	5	dsl	350	Brwstr N-45	350	6,500
JOHNSON COUNTY						
Will I Lewis Drlg Co	6	dsl	1600	M-CSCO U-20	1600	14,000
LINCOLN COUNTY						
Camay Drlg Co	5	gas	680	Natl 50-A	450	8,000
Mountain States Drlg Co Inc	2	gas-dsl	1000	Emsco J-750	–	10,000
NATRONA COUNTY						
Big Horn Drlg Co Inc	1	dsl	220	Brwstr N-4	375	4,500
	3	dsl	600	Emsco GB-250	360	6,500
A O Bullock Drlg Co	3	gas	370	Beth Twister	–	7,500
Will I Lewis Drlg Co	5	dsl	1200	"Oilwell" 76	1200	13,500
True Drlg Co	9	gas-LPG	1200	M-CSCO U-40	1200	12,000
PARK COUNTY						
Hose-Austin Drlg Corp	2	dsl	300	Natl T-32	320	5,000
Mountain States Drlg Co Inc	3	gas-dsl	600	Natl 50-A	–	7,500
	9	gas-dsl	1400	Natl 125	–	15,000
Roden & McRae Drlg Corp	4	dsl	900	Emsco GB-800	900	12,500
Rowan Drlg Co Inc	24	gas-btne	504	Natl 50	1077	8,500
SUBLETTE COUNTY						
Kent Drlg Co	1	gas	–	Natl 75 CE	1050	10,500
	2	gas	–	Natl 50	1200	7,500
Mountain States Drlg Co Inc	17	dsl	540	Natl T-32	–	6,000
Rowan Drlg Co Inc	31	gas-btne	900	Natl 75	1149	11,000
SWEETWATER COUNTY						
Camay Drlg Co	6	dsl	260	Johnson	450	5,000
Hewit-Gulick Drlg Co	3	dsl	855	Natl 50-A	900	9,000
Nye & Snell Drlg Co	1	gas	550	"Oilwell" 66	550	6,000
	2	dsl	320	Wisn M-46	320	5,000
J D Sprecher	4	dsl	1000	Natl 80-B	1000	14,000
WASHAKIE COUNTY						
Clark Drlg Co	–	dsl	–	Natl 50	525	6,500
Mountain States Drlg Co Inc	14	dsl	800	Ideco M-1000	–	10,000
J D Sprecher	6	dsl	750	Emsco A-550	750	10,000
WESTON COUNTY						
Olds & Wrather Drlg Co	1	dsl	300	Wisn Rdair Mogul	300	5,000
	3	gas	1200	Beth 450	1200	11,000
Olds & Wrather Oil Co	2	gas	675	Emsco GB-350	675	7,000
	4	dsl	300	Wisn Gnt	300	4,000
True Drlg Co	6	gas-LPG	1000	Beth Twister	750	8,500
	8	gas-LPG	800	Natl 50	500	7,500
	12	gas-LPG	1200	Wisn Gnt	800	9,500

Canadian Rotary Drilling Contractors

Arnim Drlg Ltd 133 Sixth Avenue East Calgary Alberta Can
Arrow Drlg Co 201 Oil Exchange Bldg Calgary Alberta Can
Peter Bawden Drlg Ltd 640 Seventh Ave W Calgary Alberta Can
Big Horn Drlg Ltd 6530 100th St Edmonton Alberta Can
Brinkerhoff Drlg Co Ltd 1001 Mobil Oil Bldg Calgary Alberta Can
Brown Drlg Ltd 10509 81st Ave Edmonton Alberta Can
Cactus Drlg Corp Ltd Box 853 Calgary Alberta Can
Calgary Oil Field Serv Ltd 133 6th Av SE Rm 201 Calgar Alta Can
Can American Drlg Ltd 320 Seventh Ave W Calgary Alberta Can
Cascade Drlg Co Ltd 330 Ninth Ave W Calgary Alberta Can
Central-Del Rio Oils Ltd-Drlg Div 224 9th Ave W Calgary Alta Can
Commonwealth Drlg Co Ltd 122 Eighth Ave W Calgary Alberta Can
Coultis Drlg Ltd 1724 Suffolk St Calgary Alberta Can
Double A Drlg Co Ltd 709 Eighth Ave W Calgary Alberta Can
Duke Drlg Co Ltd 239 Eighth Ave W Calgary Alberta Can
General Petroleums of Can Ltd 224 Ninth Ave W Calgary Alta Can
Gustavson Drlg Co Ltd 203 Empire Bldg Calgary Alberta Can
Guthrie McLaren Drlg Ltd 11810-124th St Edmonton Alberta Can
Hi-Tower Drlg Co Ltd 400 Lancaster Bldg Calgary Alberta Can
Hunter Drlg Ltd 602 Seventh Ave W Calgary Alberta Can
Jennings Drlg Co (Alberta) Ltd 133 Sixth Ave SE Rm 201 Alta Can
Kenyon's Drlg & Serv Co Ltd 10439 82nd Ave Edmonton Alta Can
L & J Drlg Ltd 7 Empire Bldg Calgary Alberta Can
Lohmann-Johnson Drlg Co Ltd 208 Bamlett Bldg Calgary Alta Can
Moore Drlg Co Ltd 502 Empire Bldg Calgary Alberta Can
Parker Drlg Co of Canada Ltd 409 Eighth Ave W Calgary Alta Can
Pennant Drlg Co Ltd 108-A Eighth Ave W Calgary Alberta Can
Regent Drlg Co Ltd Box 421 Edmonton Alberta Can
Rine Drlg Co of Canada Ltd 534 8th Ave SW Calgary Alberta Can
Ryland Drlg Ltd 10318 82nd Ave Edmonton Alberta Can
S & T Drlg Co Ltd 10852 82nd St Edmonton Alberta Can
Trinity Can Drlg Co 1001 F R Wbstr Bldg 237 7th Av W Clgry Albrt Ca
Trinity Canadian Drlg Co 1001 F R Wbstr Bldg 237 7th Ave W Calgary Alta Can
Union Rotary Drls (Can) Ltd 155 Wellington St Sarnia Ontario Can

Canadian Contract ROTARY Drilling Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Avail-able to Drwwks	Rated Depth with 4½" Pipe
ALBERTA						
Peter Bawden Drlg Ltd	3	dsl	270	Crdwll S	180	4,500
	18	dsl	1120	Natl 100	1140	13,000
	23	dsl	350	Emsco GB-350	450	7,000
	25	dsl	325	"Oilwell" 66	632	8,000
Can American Drlg Ltd	3	dsl	750	Natl 80-B	1200	13,000
Duke Drlg Co Ltd	2	dsl	650	Natl 50	650	8,000
	5	dsl	700	M-CSCO U-20	1386	15,000
	7	dsl	850	M-CSCO U-20	1386	15,000
	8	dsl	500	M-CSCO U-40	670	11,500
	9	dsl	500	M-CSCO U-15	650	9,000
Gardner Bros Drlg Co Inc	7	dsl	850	Natl 75	1000	12,000
	15	gas-btne	1000	"Oilwell" 96	1500	16,000
Hewgley Drlg Co	3	dsl	–	Emsco J-750	975	10,000
Rine Drlg Co of Canada Ltd	1	dsl	300	Brwstr N-45-M	720	7,500
ATHABASCA						
Hi-Tower Drlg Co Ltd	8	dsl	570	M-CSCO U-15	600	8,000
BASSANO						
General Pet of Canada Ltd	12	dsl	250	Natl T-20	250	4,800
BELLSHILL LAKE						
Big Horn Drlg Ltd	2	dsl	250	Crdwll	180	3,500
BENTLEY						
Arrow Drlg Co	6	dsl	250	Emsco GB-350	350	7,000
Peter Bawden Drlg Ltd	6	dsl	722	M-CSCO U-36A	722	8,500
BERLAND RIVER						
General Pet of Canada Ltd	18	dsl	1400	Natl 80-B	1150	12,000
BRETON						
Brown Drlg Ltd	1	dsl	275	Crdwll S	–	5,000

MILWHITE INTRODUCES MIL-FLO

a Multi-Purpose Additive

MILWHITE Technical Services proudly introduce a new concept in an improved material to provide more efficient mud systems, more stabilized well bores and more economical well drilling costs when serviced by your Milwhite engineer. A dispersant, filtrate reducer, emulsifying agent and inhibitor brought to you in a 50-pound package — Mil-Flo.

As a Dispersant Mil-Flo extends the use of the basic fresh water mud system.

As a Filtrate Reducer Mil-Flo controls down hole fluid loss in all temperature ranges to an excess of 350° F. and pressure differentials up to 5000 psi.

As an Emulsifying Agent Mil-Flo is most efficient, unaffected by high temperature and salt water contamination.

As an Inhibitor Mil-Flo is more effective than equivalent concentrations of inorganic electrolytes.

Drilling Progress Through Mud Research is Continuous at Milwhite

MILWHITE

MILWHITE MUD SALES COMPANY
HOUSTON, TEXAS
A DIVISION OF MISSISSIPPI RIVER FUEL CORPORATION

Contractor's Name	Rig No	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwks	Rated Depth with 4½" Pipe
BROOKS						
Peter Bawden Drlg Ltd	4	dsl	220	Crdwll RL	205	4,500
BUCK CREEK						
Commonwealth Drlg Co Ltd	7	dsl	750	Natl 50	530	6,500
BURNT TIMBER CREEK						
Cascade Drlg Co Ltd	14	dsl	1350	M-CSCO U-20	1350	14,000
CAMROSE						
Big Horn Drlg Ltd	3	dsl	300	Crdwll L-350	300	4,500
Ryland Drlg Ltd	2	dsl	670	Natl 50	690	7,500
CARNWOOD						
Peter Bawden Drlg Ltd	12	dsl	250	Natl T-12	225	4,000
CESSFORD						
Cascade Drlg Co Ltd	6	dsl	556	Natl T-20	233	4,500
COCHRANE						
General Pet of Canada Ltd	5	dsl	1400	Natl 80-B	1400	13,000
	11	dsl	1400	Natl 80-B	1400	12,000
CROSSFIELD						
Peter Bawden Drlg Ltd	22	dsl	775	"Oilwell" 76	795	11,500
CYNTHIA						
Ryland Drlg Ltd	4	dsl	450	Emsco 350	475	7,000
DIDSBURY						
Hunter Drlg Ltd	2	dsl	900	Crdwll J-700	1150	12,000
DRAYTON VALLEY						
Arrow Drlg Co	19	dsl	250	Emsco GB-350	480	7,000
Hi-Tower Drlg Co Ltd	4	dsl	350	Natl 50	450	6,500
Regent Drlg Co Ltd	1	dsl	260	Brwstr N-4	260	6,000
S & T Drlg Co Ltd	1	dsl	520	Natl 50-A	520	8,000
	2	dsl	440	Natl T-32	270	6,000
EAGLESHAM						
Gustavson Drlg Co Ltd	1	dsl	500	Natl 50	500	7,500
EDMONTON						
Calgary Oil Field Serv Ltd	1	dsl	120	Wisn Spr 38	180	10,000/2-1/2"
EDSON						
Peter Bawden Drlg Ltd	21	dsl	1450	"Oilwell" 96	1680	18,000
Brinkerhoff Drlg Co Ltd	21	dsl	850	Emsco GB-800	1269	13,500
ENCHANT						
Caultis Drlg Ltd	1	dsl	248	Ideco H-25-D	248	3,500
Gustavson Drlg Co Ltd	2	dsl	500	Natl T-32	250	6,500
FORT ASSINIBOINE						
Brinkerhoff Drlg Co Ltd	15	dsl	500	Natl 50-A	600	8,500
FORT ST JOHN						
Arrow Drlg Co	4	dsl	500	Emsco CB-350	600	7,000
FOX CREEK						
General Pet of Canada Ltd	10	dsl	1400	Natl 80	1000	12,000
GARRINGTON						
Brinkerhoff Drlg Co Ltd	16	dsl	370	Emsco GA-350	450	7,500
General Pet of Canada Ltd	19	dsl	435	Natl T-32	275	5,500
GILBY						
Moore Drlg Co Ltd	8	dsl	640	Beth S-55	640	7,500
GRANDE PRAIRIE						
Gustavson Drlg Co Ltd	4	dsl	850	Natl 55	850	10,000
Parker Drlg Co of Canada Ltd	4	dsl	800	"Oilwell" 76	1100	12,500
	8	dsl	400	Natl 50	500	6,500
HARMATTON						
Peter Bawden Drlg Ltd	10	dsl	900	Natl 80-B	1200	13,500
Commonwealth Drlg Co Ltd	9	dsl	1020	Ideco 700	940	10,000
	28	dsl	920	Natl 55	1000	10,000
Regent Drlg Co Ltd	6	dsl	750	Brwstr N-75	780	10,000
HUGHENDON						
Moore Drlg Co Ltd	6	dsl	400	Emsco 300	300	5,000
	10	dsl	640	Emsco 350	640	6,500
HUSSAR						
Brown Drlg Ltd	2	dsl	550	Natl 50	550	7,500
Hi-Tower Drlg Co Ltd	5	dsl	350	Natl 50	450	5,000
	9	dsl	285	Crdwll D	300	5,000
Jennings Drlg Co (Alberta) Ltd	3	dsl	880	M-CSCO U-15	880	9,000
INNISFAIL						
Duke Drlg Co Ltd	6	dsl	850	M-CSCO U-20	1386	15,000
General Pet of Canada Ltd	3	dsl	800	Natl 55	1000	10,000
Hi-Tower Drlg Co Ltd	16	dsl	800	Natl 55	1000	10,000
	10	dsl	755	"Oilwell" 76	1000	12,000
Parker Drlg Co of Canada Ltd	3	dsl	765	"Oilwell" 76	1005	12,000
IRRICANA						
Pennant Drlg Co Ltd	4	dsl	1000	Crdwll 0	650	9,500
JACK FISH LAKE						
Jennings Drlg Co (Alberta) Ltd	4	dsl	300	Beth 55 Twister	300	6,000
JOFFRE						
Moore Drlg Co Ltd	9	dsl	640	Ideco 525	640	8,500
KAYBOB						
Peter Bawden Drlg Ltd	2	dsl	810	Natl 55	810	10,000
	15	dsl	950	M-CSCO U-40	795	11,500
	26	dsl	775	"Oilwell" 76	795	11,500
Brinkerhoff Drlg Co Ltd	1	dsl	625	Emsco GC-500	846	10,000
	18	dsl	625	Emsco GC-500	846	10,000
Pennant Drlg Co Ltd	1	dsl	1050	M-CSCO U-40	775	11,500
	6	dsl	1350	M-CSCO U-40	1200	11,500
Trinity Canadian Drlg Co	7	dsl	875	Emsco GC-500	720	10,000
KEYSTONE						
Peter Bawden Drlg Ltd	5	dsl	440	Natl T-32	270	5,500
Cascade Drlg Co Ltd	16	dsl	278	M-CSCO U-34	311	5,000
Rine Drlg Co of Canada Ltd	2	dsl	370	Brwstr N-55	720	8,500
Ryland Drlg Ltd	1	dsl	600	Emsco 450	640	7,500
KINUSO						
Cascade Drlg Co Ltd	7	dsl	556	Natl 50A	556	7,500
LEDUC						
Moore Drlg Co Ltd	2	dsl	600	Emsco 450	640	7,500
LLOYDMINSTER						
Peter Bawden Drlg Ltd	14	dsl	142	Crdwll	100	2,500
LOBSTICK						
Commonwealth Drlg Co Ltd	11	dsl	260	Ideco H-40D	300	5,500
LODGEPOLE						
Regent Drlg Co Ltd	30	dsl	260	Ideco H-40	260	6,000
MARBLE MOUNTAIN						
General Pet of Canada Ltd	14	dsl	400	Crdwll OA	500	6,500
MOOSE MOUNTAIN						
Commonwealth Drlg Co Ltd	26	dsl	1275	Natl 80B	1410	12,000
NAMAO						
Big Horn Drlg Ltd	1	dsl	300	Crdwll S 350	300	5,000
NAMPA						
Commonwealth Drlg Co Ltd	10	dsl	550	Ideco H-35D	300	6,500
	22	dsl	750	Natl 50	530	6,500
NEVIS						
Commonwealth Drlg Co Ltd	8	dsl	690	Brwstr N-7	600	8,000
NORDEGG						
Parker Drlg Co of Canada Ltd	9	dsl	1260	Natl 110	1890	16,000
NORMANDVILLE						
Gustavson Drlg Co Ltd	5	dsl	420	Natl T-45	420	7,500
PEACE RIVER						
Peter Bawden Drlg Ltd	16	dsl	650	"Oilwell" 64B	530	6,000
Moore Drlg Co Ltd	5	dsl	600	M-CSCO U-15	600	7,500
PEMBINA						
Peter Bawden Drlg Ltd	1	dsl	415	Natl T-32	275	6,000
	8	dsl	300	Natl T-32	300	6,500
	17	dsl	650	"Oilwell" 64B	530	6,000
Brinkerhoff Drlg Co Ltd	12	dsl	200	Natl T-32	300	6,000
Cactus Drlg Corp Ltd	3	dsl	420	Natl T-32	280	6,000
Cascade Drlg Co Ltd	1	dsl	556	Natl 50	556	6,500
	3	dsl	556	Natl 50	556	6,500
	8	dsl	556	Natl 50	556	6,500
	10	dsl	556	Natl 50	556	6,500
Commonwealth Drlg Co Ltd	3	dsl	690	Natl 50	600	6,500
	17	dsl	630	Emsco GB-350	720	6,000
	25	dsl	425	M-CSCO U-34D	300	5,500
Gustavson Drlg Co Ltd	3	dsl	275	Ideco H-40	300	6,500
Parker Drlg Co of Canada Ltd	11	dsl	400	Natl 50	500	6,500
PENHOLD						
Pennant Drlg Co Ltd	2	dsl	1155	Brwstr N-7	755	8,500
PINCHER CREEK						
Brinkerhoff Drlg Co Ltd	8	dsl	900	Natl 110	1200	15,000
	19	dsl	850	Emsco A-800	1269	14,000
	22	dsl	900	Natl 110	1450	15,000
Jennings Drlg Co (Alberta) Ltd	2	dsl	300	Beth C-50	300	6,000
PROVOST						
Arrow Drlg Co	8	dsl	250	Emsco GB-350	480	7,000
RED DEER						
General Pet of Canada Ltd	6	dsl	400	Natl 50-A	500	7,000
Parker Drlg Co of Canada Ltd	5	dsl	420	Natl 50	420	7,000
RIMBEY						
Regent Drlg Co Ltd	28	dsl	500	Natl 50A	520	7,000
ROCKY MOUNTAIN HOUSE						
Regent Drlg Co Ltd	26	dsl	260	Ideco H-40	260	6,000
ST. ALBERT						
General Pet of Canada Ltd	4	dsl	625	Natl 50-A	650	7,500
SEDGEWICK						
Regent Drlg Co Ltd	21	dsl	260	Brwstr N-4	260	9,000/3-1/2"
STETTLER						
Parker Drlg Co of Canada Ltd	6	dsl	420	"Oilwell" 52-T	420	6,500
SUNDRE						
General Pet of Canada Ltd	15	dsl	1400	Natl 55	1050	10,000
	17	dsl	1400	Natl 55	1050	10,000
SUNNYNOOK						
Commonwealth Drlg Co Ltd	14	dsl	580	Ideco H-40D	660	5,500
SWAN HILLS						
Peter Bawden Drlg Ltd	9	dsl	1000	M-CSCO-U-40	1000	12,000
Cascade Drlg Co Ltd	12	dsl	1350	Natl 80B	1350	14,000
	17	dsl	1190	Natl 75	1190	12,000
Commonwealth Drlg Co Ltd	21	dsl	1250	Ideco 7-11	900	10,500
	23	dsl	905	Emsco GC-500	800	9,500
Double-A Drlg Co Ltd	2	dsl	800	Ideco H-525	600	9,000
Hi-Tower Drlg Co Ltd	1	dsl	525	"Oilwell" 66	800	8,000
	3	dsl	525	"Oilwell" 66	600	8,000
	7	dsl	525	"Oilwell" 66	800	8,000
Kenyon's Drlg & Serv Ltd	11	dsl	–	Crdwll 151	–	5,000/3-1/2"
Parker Drlg Co of Canada Ltd	2	dsl	800	"Oilwell" 76	1275	11,500
	12	dsl	650	"Oilwell" 66	800	9,000
Regent Drlg Co Ltd	2	dsl	520	Brwstr N-55	520	8,000
	3	dsl	720	Brwstr N-55	520	8,000
	8	dsl	750	Brwstr N-75	780	10,000
	9	dsl	750	Brwstr N-75	780	10,000
	25	dsl	750	Brwstr N-75	780	10,000
S & T Drlg Co Ltd	3	dsl	900	Natl 55	900	9,000
VALLEYVIEW						
Peter Bawden Drlg Ltd	7	dsl	720	Natl 55	720	9,500
	20	dsl	970	"Oilwell" 76	795	11,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Guthrie McLaren Drlg Ltd	2	dsl	500	"Oilwell" T-52	350	7,500
VIRGINIA HILLS						
Parker Drlg Co of Canada Ltd	1	dsl	800	"Oilwell" 76	1275	11,500
	7	dsl	600	Natl 55	670	9,000
WATERTON LAKES						
Commonwealth Drlg Co Ltd	1	dsl	1350	Natl 110	1500	14,000
Regent Drlg Co Ltd	7	dsl	1200	Natl 125	1500	15,000
WAYNE						
Commonwealth Drlg Co Ltd	13	dsl	630	Emsco GA-350	720	6,500
WHITECOURT						
Arnim Drlg Ltd	1	dsl	300	Crdwll J-450	350	10,000/3-1/2"
Arrow Drlg Co	21	dsl	1250	Emsco J-1250	1400	14,000
Commonwealth Drlg Co Ltd	19	dsl	735	Natl 50-A	790	9,500
Regent Drlg Co Ltd	24	dsl	720	Brwstr N-7	520	8,000
WILLESDEN GREEN						
Moore Drlg Co Ltd	7	dsl	960	Beth S-55	640	8,500
WINTERING HILLS						
Cactus Drlg Corp Ltd	4	dsl	215	Emsco GB-160	275	4,000
Jennings Drlg Co (Alberta) Ltd	1	dsl	300	Beth C-50	300	6,000
WOKING						
Pennant Drlg Co Ltd	5	dsl	1050	M-CSCO U-40	900	11,500
BRITISH COLUMBIA PROVINCE						
Trinity Canadian Drlg Co	1	dsl	995	Emsco GC-500	770	10,000
	3	dsl	720	Emsco 350	670	7,000
BLUEBERRY						
Arrow Drlg Co	26	dsl	975	Emsco GB-800	1200	13,000
Cactus Drlg Corp Ltd	6	dsl	555	Emsco GB-350	555	7,000
	7	dsl	675	Emsco GB-350	675	7,500
Calgary Oil Field Serv Ltd	2	dsl	120	Wlsn Spr 38	180	10,000/2-1/2"
BUSH MOUNTAIN						
General Pet of Canada Ltd	7	dsl	1400	Natl 80-B	1300	13,000
CHARLIE LAKE						
Cascade Drlg Co Ltd	4	dsl	556	Natl 50A	556	7,500
	11	dsl	278	Crdwll D	311	5,500
CHINCHAGUA RIVER						
Trinity Canadian Drlg Co	4	dsl	990	Natl 80-B	990	12,000
CLARKE LAKE						
Brinkerhoff Drlg Co Ltd	20	dsl	370	Natl 50A	450	8,500
DAWSON CREEK						
Trinity Canadian Drlg Co	5	dsl	1250	Emsco A-800	1150	15,000
FT. NELSON						
Arrow Drlg Co	7	dsl	975	Emsco GC-500	900	9,000
Peter Bawden Drlg Ltd	19	dsl	580	Emsco GB-500	530	8,500
Commonwealth Drlg Co Ltd	20	dsl	1270	Ideco 7-11	900	10,500
FT. ST. JOHN						
Cactus Drlg Corp Ltd	5	dsl	675	Emsco GB-500	675	8,500
Cascade Drlg Co Ltd	18	dsl	933	Ideco 7-11	933	12,000
Commonwealth Drlg Co Ltd	15	dsl	800	Brwstr N-7	600	8,000
Guthrie McLaren Drlg Ltd	1	dsl	300	"Oilwell" T-52	350	7,000
Parker Drlg Co of Canada Ltd	10	dsl	400	Natl 50-A	500	7,000
Regent Drlg Co Ltd	5	dsl	720	Brwstr N-7	520	8,000
JEDNEY						
Cascade Drlg Co Ltd	2	dsl	610	Wlsn Roadair	610	8,500
NIG CREEK						
Peter Bawden Drlg Ltd	24	dsl	650	M-CSCO U-15	530	7,500
PETITOT RIVER						
Brinkerhoff Drlg Co Ltd	14	dsl	370	Emsco GB-500	600	8,500
QUEEN CHARLOTTE ISLANDS						
Cascade Drlg Co Ltd	5	dsl	556	Natl 50A	556	7,500
MANITOBA PROVINCE						
Moore Drlg Co Ltd	3	dsl	320	Brwstr N-4	190	5,000
VIRDEN						
Coultis Drlg Ltd	3	dsl	248	Wgnr Mrhse TD2	150	3,000
NORTHWEST TERRITORY						
Peter Bawden Drlg Ltd	11	dsl	250	Natl T-32	300	5,000
ONTARIO PROVINCE						
ESSEX						
Union Rotary Drlr (Can) Ltd	1	gas-LPG	240	Natl 40	180	4,000
MEDICINE RIVER						
Lahmann-Johnson Drlg Co Ltd	2	dsl	218	M-CSCO U-15	500	9,000
WINDSOR						
Eakle & Holder Drlg Co	4	dsl	300	Natl T-20	300	5,500
SASKATCHEWAN PROVINCE						
Can American Drlg Ltd	1	dsl	350	Natl T-32	335	6,000
	2	dsl	650	Natl T-55	975	10,000
	4	dsl	260	Natl T-20	260	5,000
	5	dsl	375	Natl T-32	320	6,000
	6	dsl	275	Natl T-12	260	3,500
	7	dsl	260	Natl T-20	260	5,000
Double-A Drlg Co Ltd	1	dsl	340	Ideco H-30	265	4,500
	3	dsl	340	Ideco H-40	265	6,000
L & J Drlg Ltd	5	dsl	300	Natl 50	440	6,500
ALAMEDA						
Commonwealth Drlg Co Ltd	24	dsl	520	Natl 50	600	6,000
General Pet of Canada Ltd	1	dsl	250	Natl 50	525	6,500
CARNDUFF						
Commonwealth Drlg Co Ltd	2	dsl	490	Natl 50	530	6,000
	4	dsl	260	Ideco H-40D	300	6,000
General Pet of Canada Ltd	2	dsl	250	Natl T-20	250	4,800
Hunter Drlg Ltd	3	dsl	450	Crdwll	260	6,000
CARLYLE						
Kenyon's Drlg & Serv Ltd	12	dsl	–	Frnks Comet 658	–	5,000
ESTEVAN						
General Pet of Canada Ltd	9	dsl	375	Natl T-25	250	5,500
Moore Drlg Co Ltd	4	dsl	330	Emsco 300	300	5,000
FROBISHER						
Regent Drlg Co Ltd	4	dsl	260	Brwstr N-4	260	6,000
	27	dsl	260	Brwstr N-4	260	6,000
GOODWATER						
Regent Drlg Co Ltd	22	dsl	260	Brwstr N-4	260	6,000
	23	dsl	260	Brwstr N-4	260	6,000
HASTINGS						
Commonwealth Drlg Co Ltd	18	dsl	260	Ideco H-25D	300	4,500
KAYVILLE						
Central-Del Rio Oils Ltd Drlg Div	1	dsl	500	Natl 50	500	6,500
KINDERSLEY						
Rine Drlg Co of Canada Ltd	3	dsl	220	Crdwll L Trailer	248	4,000
LAMPMAN						
General Pet of Canada Ltd	20	dsl	275	Emsco GB250T	275	5,000
L & J Drlg Ltd	5	dsl	300	Crdwll S	440	4,500
MANOR						
Commonwealth Drlg Co Ltd	12	dsl	260	Natl T-32	300	5,500
MIDALE						
Guthrie McLaren Drlg Ltd	3	dsl	900	M-CSCO U-34	600	7,000
Regent Drlg Co Ltd	29	dsl	260	Brwstr N-4	260	6,000
PEMBINA						
Commonwealth Drlg Co Ltd	16	dsl	800	Emsco GB-350	720	7,000
RAVEN RIVER						
Lahmann-Johnson Drlg Co Ltd	1	dsl	550	"Oilwell" 66	550	9,000
ROCANVILLE						
Coultis Drlg Ltd	2	dsl	250	Wlsn Torcair	250	4,000
STEELMAN						
Commonwealth Drlg Co Ltd	5	dsl	260	Emsco GA-250T	310	5,000
	6	dsl	690	Ideco M-750	600	7,000
Ryland Drlg Ltd	3	dsl	320	Natl T-32	320	6,000
WAUCHOPE						
General Pet of Canada Ltd	8	dsl	250	Natl T-25	250	5,000
WEYBURN						
Central-Del Rio Oils Ltd Drlg Div	2	dsl	285	Crdwll TR 66	245	5,000
Hunter Drlg Ltd	1	dsl	450	Crdwll	260	6,000

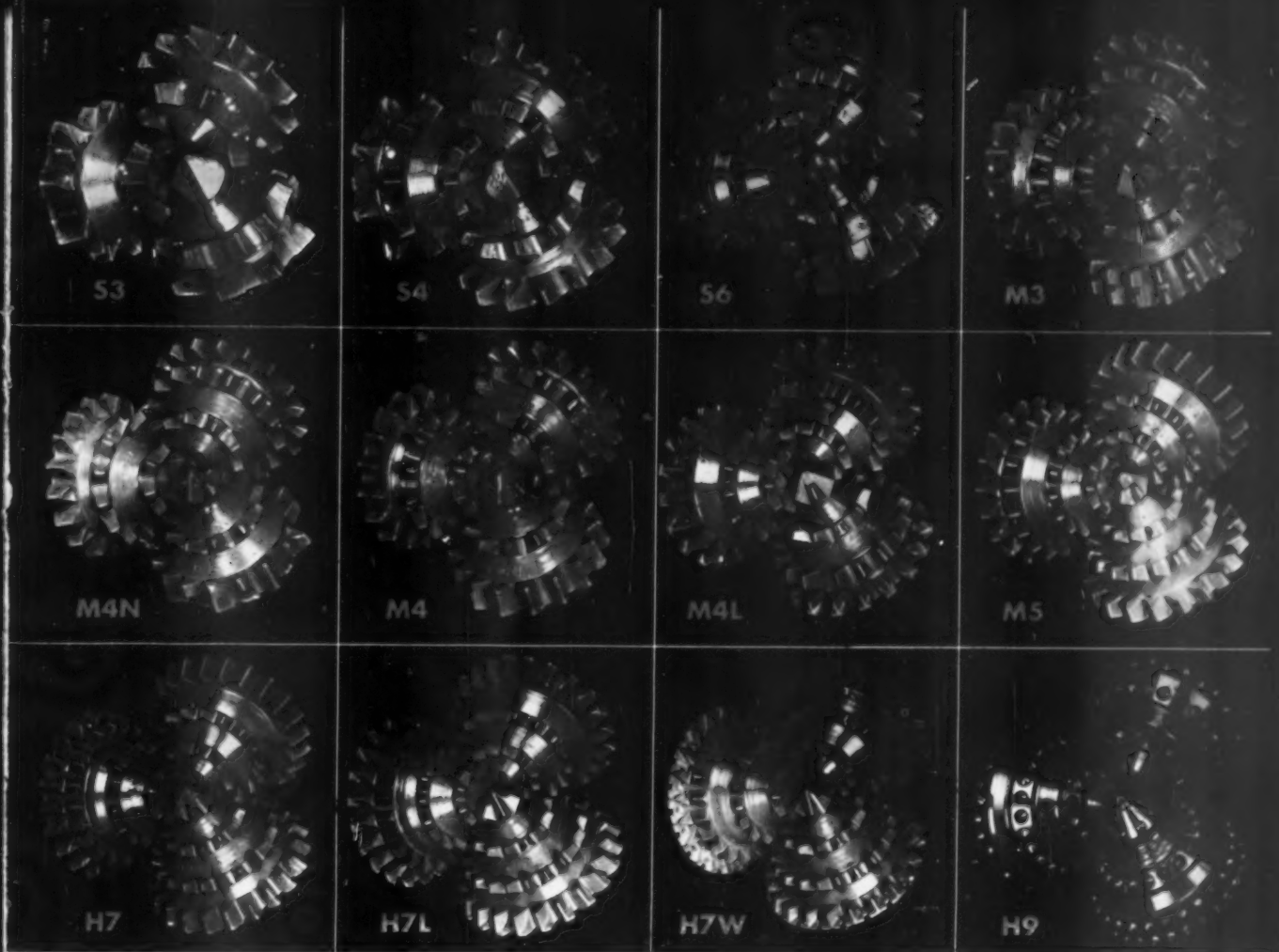
Some Contract Rigs in Foreign Service

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ARGENTINA						
Kermac Drlg Co of Venezuela	3	dsl	800	Natl 75	1000	11,500
	28	dsl	800	Natl 75	1000	11,500
	41	dsl	800	Natl 75	1000	11,500
	42	dsl	800	Natl 75	1000	11,500
	51	dsl	800	Natl 75	1000	11,500
AUSTRALIA						
Delta Drlg Co	41	dsl	1300	Natl 130	1400	16,000
BOLIVIA						
Big Chief Drlg Co	29	dsl	1875	Emsco 1250	1815	16,000
	31	gas	1545	Emsco 800	1515	13,500
	37	gas	1875	Emsco 1250	1815	16,000
BRAZIL						
ALAGOAS						
Brantly Drlg Co (Intl) Inc	1	dsl	850	"Oilwell" 52-T	500	7,000
Haney-Williams Drlg Corp S A	1	–	600	Crdwll 0	900	10,000
	2	–	600	Crdwll 0	900	10,000
	3	–	600	Crdwll 0	900	10,000
BRITISH HONDURAS						
Kerr-McGee Oil Ind Inc	50	dsl	1000	Natl 55	770	10,000
COLOMBIA						
An-Son Drlg Co	C-2	dsl	1300	Crdwll 0	700	9,000
	C-3	dsl	1000	Crdwll J-450	500	7,000
	C-4	dsl	1050	Natl 55	1050	10,500
	C-5	dsl	746	Ideco H-40D	496	6,500
	C-6	dsl	600	Frnks 658-DTD	300	5,000
	C-7	dsl	490	Failing MGG	300	3,000
	C-8	dsl	566	Ideco H-25	376	4,000
	C-9	dsl	354	Ideco H-30	177	5,000
EL CENTRO						
Llano Drlg Co	8	dsl	800	Ideco H-30	300	4,500
COSTA RICA						
Drlg & Expl Co Inc	42	dsl	1800	"Oilwell" 96	2000	18,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Avail- able to Drwwks	Rated Depth with 4½" Pipe
CUBA						
C J Simpson Drlg Co	1C	dsl-gas	–	Natl T-32	320	5,000
	2C	dsl-gas	–	M-CSCO U-40	900	14,000
	3C	dsl-gas	–	Emsco D-450	700	8,500
GUATEMALA						
Kerr-McGee Oil Ind Inc	14	dsl	695	Natl 50	630	9,000
ITALY						
ABRUZZO						
Delta Overseas Drlg Co	1	dsl	900	Ansaldo 2000	600	7,000
	2	dsl	260	Ideco H-30	300	4,500
SICILY						
Delta Overseas Drlg Co	4	dsl	900	Emsco 800	900	11,000
VENETO						
Delta Overseas Drlg Co	3	dsl	500	Emsco GB-500	500	8,500
JORDAN						
Parker Drlg Co	46	gas	–	Natl 75	700	10,000
LIBYA						
Camay Drlg Co	–	dsl	1200	Natl 100	1200	12,000
Camdrill International Inc	–	dsl	255	Ideco H-30-D	300	4,500
	2	dsl	1000	Natl 110	2400	13,000
"Desert Star"		dsl	1290	Ideco 525-D	860	9,000
MEXICO						
Walters Drlg Co Inc	11	gas	150	Mayhew 1000	150	600/2-3/8"
TURKEY						
Drlg & Expl Co Inc	–	dsl	1250	Natl 80-B	1500	14,000
	40	dsl	700	Emsco GB-500	1050	7,500
VENEZUELA						
Santa Fe Drlg Co	23	dsl	300	Ideco H-40	300	6,000
ANZOATEGUI						
Helmerich & Payne Inc	61	dsl	–	Natl 125	–	–
	63	stm	–	Natl 34-10	–	–
	64	stm	–	Natl 34-10	–	–
	65	dsl	–	Natl 50-A	–	–
	68	stm	–	Natl 34-10	–	–
BARINAS						
Helmerich & Payne Inc	62	dsl	–	Natl 125	–	–
	67	dsl	–	Natl 110	–	–
Perforaciones Delta, C A (Caracas, Venezuela)	10	dsl	260	Crdwll 0	450	7,500
	22	dsl	520	Natl 80-B	800	10,000
	23	dsl	520	Natl 100	900	12,000
EASTERN						
Perforaciones Delta, C A (Caracas, Venezuela)	1	dsl	260	Ideco H-40-D	400	6,500
	2	dsl	260	Ideco H-40-D	400	6,500
	3	dsl	260	Failing 2066	–	1,500
	4	dsl	260	Ideco H-40-D	400	6,500
	5	stm	1200	Emsco UBLS	1690	15,000
	7	dsl (wo)	260	Ideco H-30-D	300	4,500
	17	dsl	200	Crdwll R	250	4,500
	18	dsl	200	Crdwll R	250	4,500
	19	dsl	260	Crdwll TR	250	6,000
	20	dsl	260	Crdwll TR	250	6,000
	21	dsl	260	Crdwll TR	250	6,000
GULF OF PARIA						
Perforaciones Delta, C A	Bge 12	dsl	1560	Emsco J-1250	1250	15,000
LAKE MARACAIBO						
Kermac Drlg Co of Venezuela	V-1	dsl	2000	Emsco A-800-E	1500	13,000
	V-2	dsl	2000	Emsco A-1100-E	1500	16,000
Perforaciones Delta, C A	Bge 13	dsl	1040	Emsco J-1250	1250	15,000
	Bge 14	dsl-elec	2000	Emsco ECB	1200	15,000
	Bge 15	dsl-elec	2000	Emsco ECB	1200	15,000
	Bge 16	dsl-elec	2000	Emsco ECB	1200	15,000
MONAGAS						
Helmerich & Payne Inc	66	dsl	–	Natl 125	–	–
WESTERN						
Perforaciones Delta, C A (Caracas, Venezuela)	8	dsl	600	Emsco G-500	500	8,000
	9	dsl	1000	Emsco GB-800	900	12,000
	11	dsl	130	Natl T-12	120	2,500

U. S. Rotary Workover Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Avail- able to Drwwks	Workover Depth, Ft
ARKANSAS						
LAFAYETTE COUNTY						
McCalman Drlg Co Inc	1	dsl	–	Brwstr N-4	300	8,000
MILLER COUNTY						
Johnson Drlg & Serv Co	2	dsl	500	Beth Twister	300	12,500
CALIFORNIA						
BAKERSFIELD						
Tine Gaiser Drlg Co	A	dsl	600	Natl 50	500	9,500
	B	dsl	800	Emsco GB-500	700	13,000
	C	btne	300	–	225	5,000
General Prod Serv Inc	10	dsl	300	Hopper GTA	300	7,500/2-7/8"
	12	dsl	300	Hopper M	380	12,000/2-7/8"
Oil Well Serv Co	1-A	dsl	500	Ideco 40	300	13,000
	2-A	dsl	400	Ideco 40	300	13,000
	11	LPG	400	Ideco 30	280	8,000
	15	LPG	400	Ideco 30	300	10,000
KERMAN						
Oil Well Serv Co	4-A	dsl	300	Ideco 30	300	8,000
	57	dsl	300	Ideco 35 Drive-In	300	12,000
KERN COUNTY						
Drlg & Prod Co	1	dsl	325	Crdwll Trlrig	420	12,500
	1	dsl	400	Crdwll	350	6,000
	2	dsl-gas-gaso	400	Crdwll 0	432	6,000
John S Hagestad Drlg Co	1	dsl	570	Emsco GB-350	400	7,000
	4	dsl	680	Ideco H-525	440	7,500
LONG BEACH						
Macrate Prod Co	2	dsl	190	Ideco H-30-AD	190	6,000
	7	gas-LPG	300	Wgnr-Mrhse 15-40	250	8,000
	8	dsl	300	Wgnr-Mrhse 15-40	300	10,000
Oil Well Serv Co	9	LPG	400	Ideco 30	300	10,000
LOS ANGELES						
John S Hagestad Drlg Co	2	dsl	540	Ideco H30-D	340	4,500
	3	dsl	625	Emsco GB 350	400	7,000
VENTURA						
Terminal Drlg & Prod Co	18	dsl	500	Ideco H-525D	600	16,000
WILMINGTON						
Terminal Drlg & Prod Co	1	gas	620	Natl 50	450	12,000
	12	gas-LPG	320	Ideco H-30D	190	9,000
	14	gas-LPG	140	Ideco H-25D	125	3,500
	17	dsl	500	Wlsn Mogul	350	12,000
ILLINOIS						
CENTRALIA						
T M Pruett Drlg Contr	1	dsl	300	M-CSCO U-15	300	8,000
HAMILTON						
E F Moran Inc	5	btne	145	Failing "2500"	–	2,500/3-1/2"
WHITE						
E F Moran Inc	4	btne	300	Brwstr N-3	300	3,500/3-1/2"
INDIANA						
DAVIESS COUNTY						
Henry Gwaltney Drlg Co	3	gas	100	–	100	1,500
GIBSON COUNTY						
Henry Gwaltney Drlg Co	1	dsl	200	Natl T-12	165	3,000
KNOX COUNTY						
Henry Gwaltney Drlg Co	2	gas-prop	200	Crdwll	165	3,000
LOUISIANA						
CADDO PARISH						
Johnson Drlg & Serv Co	1	dsl	200	Beth Breeze	200	10,000
EUNICE PARISH						
Harris Drlg Co Inc	3	gas	200	Crdwll RL	200	12,000/2"
	5	gas	155	Crdwll K	155	10,000/2"
RAYNE PARISH						
Sunnyland Contg Co Inc	8	gas	422	Crdwll D	422	13,000/2"
SHREVEPORT						
Lunsford Drlg Co	1	LPG	185	Brwstr N-3	145	4,000
	2	LPG	145	Wlsn Spr	145	2,500
SPRINGHILL						
Crusader Drlg & Serv Inc	9	dsl	220	Wlsn Mogul	220	1,200
MICHIGAN						
OCEANA COUNTY						
Bernhardt Drlg Co	1	dsl	300	Failing 2500	300	3,500/2-7/8"
MISSISSIPPI						
BOLTON						
Graham Bros Oil Well Serv	6	dsl	180	Crdwll K-201	190	13,500
FORREST						
Wm Hawkins Drlg Co	2	gas-btne	300	M-CSCO U-15	485	16,000
MADISON						
E B Duncan Drlg & Well Serv Co Inc	1	LPG	150	Frnks 5000	450	6,500/2-1/2"
NATCHEZ						
Thornbrugh Well Serv Co	9	LPG	125	Wlsn Mogul	125	10,000
	21	dsl	145	Wlsn Gnt	200	12,000
RANKIN COUNTY						
Rimrock Tidelands Inc	19	dsl	1410	Beth MC-950	1200	18,000
MONTANA						
GLENDIVE						
Signal Oilfield Serv Inc	10	dsl	250	Frnks 658/65	250	12,000
NEW MEXICO						
FARMINGTON						
Signal Oilfield Serv Inc	6	LPG	150	Frnks 65/44	200	8,000
LEA COUNTY						
Pico Drlg Co	4	gas-btne	180	Wlsn Mogul	300	4,000
NORTH DAKOTA						
DIVIDE COUNTY						
Rutledge Drlg Co	6	gas-btne	362	Emsco 350	675	8,000
McHENRY						
Exploration Drlg Co	9	gas	310	Beth S-50	225	5,500



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W. HEMISPHERE: Security International C.A., Caracas, Venezuela...
E. HEMISPHERE: Security International C.A., London, England.

Available Through Your Favorite Accredited Supply Store

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Workover Depth, Ft
RENVILLE						
Exploration Drlg Co	6	gas	310	Beth S-50	225	5,500
OHIO						
NEW PHILADELPHIA						
Glenn Gillespie & Sons	7	dsl	300	Frnks 658TRD	225	8,000/2-7/8"
WAYNE COUNTY						
D J Bronyan Co	1	dsl	600	Wichtex E-75	145	3,000
OKLAHOMA						
ARDMORE						
Quad Drlg Co	1	gaso-btne	1000	Frnks Gnt Clipper	275	15,000
	2	btne	150	Crdwll KL	125	6,500
CREEK COUNTY						
Wade Drlg Co Inc	1	dsl	225	Crdwll L	185	3,500
GRADY COUNTY						
Dick Wegener Drlg Co	4	gas-dsl	1900	Natl 130	1900	22,000
HEALDTON						
J D Speer	1	dsl	104	Wlsn Spr	104	2,000/3-1/2"
HUGHES						
R W I T Drlg Co	1	gas-LPG	150	Crdwll	150	3,000/3-1/2"
SHIDLER						
Glenn Gillespie & Sons	1	gas	360	M-CSCO U-34	225	8,000/2-7/8"
TEXAS						
ALICE						
Mohawk Oil Well Serv	2	dsl	125	Wlsn Spr	125	7,500
	3	dsl	125	Wlsn Spr	125	7,500
	4	dsl	125	Wlsn Spr	125	7,500
W M & W Well Serv Co	9	dsl	300	Wlsn Spr	150	4,000
ALVIN						
Rocket Well Serv	1	LPG	200	Frnks 658	200	12,000/2"
BIG LAKE						
Pool & Gerlich Drlg Co	D-1	gas	260	M-CSCO U-34	300	5,000
CARRIZO SPRINGS						
Sutton Prod Co	9	–	–	–	–	4,000
CAYUGA						
Mobile Well Serv	3	LPG	185	TIW	300	10,000
	10	LPG	185	Frnks 65-44 DTD	200	9,000
CHARLOTTE						
Sutton Prod Co	8	gas-gaso	–	Wlsn	125	5,000
COCHRAN						
Sitton & Norton Drlg Co	1	btne	270	Wlsn Gnt	270	5,600
CONROE						
Spur Well Serv Co	2	gas-gaso	100	Frnks 65-TD	180	8,000
COPANO BAY						
Camden Drlg Co	Bge 2	dsl	600	Natl T-32	300	15,000
DUVAL COUNTY						
J E Hillier	3	dsl	800	Crdwll KM-250	400	8,500/3-1/2"
ECTOR						
Beckman Inc	–	–	250	Natl T-20	200	10,000
ELKHART						
Mobile Well Serv	2	LPG	185	Wlsn Spr	200	9,000
GARZA						
Calco Drlg Co	3	gas-btne	275	Emsco GB-250T	250	5,500
	5	dsl	325	Beth S-45-E	300	5,500
HARRIS						
WLB Drlg Co	2	gas-gaso-btne	370	M-CSCO U-34	230	4,500
HOUSTON						
French Drlg & Well Serv	2	gas-LPG	360	Wlsn Mogul	225	12,000
Mac Drlg Co	5	gas-gaso-btne	275	Beth S-45	450	15,000
Spur Well Serv Co	1	gas-gaso	100	Frnks 65-TD	180	8,000
	3	gas-LPG-dsl	250	Frnks 137	580	12,000
Stewart's Casing Crew	1	gas-gaso	–	Cooper E	60	8,000/2"
	3	gas-gaso	–	Cooper 420	145	11,000/2"
	5	gas-gaso	–	Cooper 420	145	11,000/2"
	6	gas-gaso	–	Cooper 420	145	11,000/2"
	9	gas-gaso	–	–	145	10,000/2"
JACKSON COUNTY						
Mac Drlg Co	5	gas-gaso-btne	275	Beth S-45	450	7,500
S D & S Drlg Co Inc	1	gas-btne	600	Ideco H-35	272	6,500
KILGORE						
Robert M Bass Drlg Contr	5	gas-LPG	300	Wlsn Giant	300	10,000
J-B Swabbing Co Inc	1	gas	300	Wlsn Gnt	300	12,000
	9	gas	200	Wlsn Mogul	250	10,000
LaPORTE						
Columbia Drlg Co	Bge 1	dsl	800	"Oilwell" 76	750	18,000
LIBERTY						
Texas Workover & Oilwell Serv Co	2	gas-LPG	475	Brwstr N-4	450	14,000
LIPSCOMB						
Wagner & Wyant Drlg Co Inc	3	dsl	300	M-CSCO U-34	300	5,000
LITTLEFIELD						
Sitton & Norton Drlg Co	1	btne	270	Wlsn Gnt	270	10,000
ODESSA						
J E Perkins Inc	3	gas-LPG	175	Wlsn Gnt	250	10,000
	4	gas-LPG	450	M-CSCO U-15	450	15,000
	5	gas-LPG	400	Wlsn Gnt 42	400	12,500
	6	gas-LPG	450	Wlsn Gnt 42	450	15,000
RIO GRANDE CITY						
J & M Well Serv	3	gas-gaso-LPG	67	Cooper E-563	67	6,500
	4	gas-gaso-LPG	67	Wlsn Spr	67	7,500
	5	gas-gaso-LPG	67	Wlsn Spr	67	7,500
ROSENBERG						
Savely Workover & Drlg Inc	2	LPG-gas	265	Natl T-12	230	11,000/2-7/8"
	3	LPG-gas	200	M-CSCO U-34	235	12,500
STOCKDALE						
Sutton Prod Co	5	gas-gaso	–	Wlsn	125	3,500
SULPHUR SPRINGS						
Dood Emerson Well Serv & Gen Contg	2	LPG	180	Wlsn Spr	145	4,500
WARD COUNTY						
Pico Drlg Co	1	dsl	368	Brwstr N-4	216	5,000
WASKOM						
James R Brown Well Serv	3	LPG	75	Wlsn Spr 38	220	12,000
WICHITA FALLS						
McAlister Well Serv	16	LPG	80	Reverse Circ Rig	–	6,000
WINK						
Permian Well Serv Inc	1	LPG	200	Crdwll RL	290	12,000
WINNSBORO						
Winnsboro Well Serv Co	F-1	btne	145	Frnks Rocket	178	7,200/2-1/2"
	F-2	btne	145	Frnks Rocket	178	7,200/2-1/2"
YOUNG						
Jess P Cross Drlg Contr	1	gas-btne	250	Wlsn Gnt	230	4,500/3-1/2"
WYOMING						
CAMPBELL COUNTY						
Oien Oil Corp	3	dsl	500	Natl T-20	280	5,000
CASPER						
M E Billings Well Serv Inc	1	gas	165	Frnks 658	180	8,000
CODY						
Wyoming Well Serv Inc	24	gas	200	Frnks 5039	220	8,000
GLENROCK						
Dyer Drlg Co	4	dsl	185	Failing 66	300	3,500
HOT SPRINGS COUNTY						
J D Sprecher	5	dsl	350	Brwstr N-45	350	6,500

Canadian Rotary Workover Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Workover Depth, Ft
ALBERTA PROVINCE						
BELLSHILL LAKE						
Redwell Serv Co Ltd	13	dsl	260	Crdwll L	180	10,000
CAMROSE						
Redwell Serv Co Ltd	14	dsl	260	Crdwll L350	260	13,000
EDMONTON						
Coralta Drlg Ltd	1	gas	180	Failing 1500	180	1,500
	2	gas	180	Failing 1500	180	1,500
RED DEER						
Chupp Well Serv Ltd	5	–	–	Ideco M-25-D	–	10,000
SWAN HILLS						
Kenyon's Drlg & Serv Ltd	11	dsl	–	Crdwll 151	350	10,000
WETASKIWIN						
Jennings Drlg Co (Alberta) Ltd	1	dsl	300	Beth C-50	300	7,000/3-1/2"
	2	dsl	300	Beth C-50	300	7,000/3-1/2"
	3	dsl	880	M-SCO U-15	880	10,000/3-1/2"
SASKATCHEWAN PROVINCE						
CARLYLE						
Kenyon's Drlg & Serv Ltd	12	dsl	–	Frnks Comet 658	250	9,000

U. S. Cable Tool Drilling Contractors

A

Allen Drlg Co 4410 Venable Ave Charleston 4 W Va
Duke Anderson Drlg Co Box 379 Okla City Okla
Ashton Well Serv Box 541 Iowa Pk Tex

B

B & B Drlg Co Whitlash Montana
Baggett Drlg Co 4305 Univ Dr Wichita Falls Tex
R P Baker Drlg Co Box 454 El Dorado Kans
C H Baker Box 91 Toronto Kans
Bar-Lee Drlg Co Box 7264 Tulsa Okla
Bartles-Johnstone Oil Co Box 743 Bartlesville Okla
Barry Well Drlg Co West Star Rt Fallon Nev
Bennett Drlg Co 1381 E 26th St Tulsa 14 Okla
Bernhardt Drlg Co 2469 Grand River Detroit 1 Mich
Bill's Drlg Serv 617 Union Natl Bldg Wichita 2 Kans
Bodard Drlg Co 313 Masonic Bldg Shawnee Okla
Brown & Thorp Drlg Co Box 1359 McCamey Tex
Butler County Drlg Co 506 Orpheum Bldg Wichita Kans

C

Capitol Drlg & Serv Co 854 S Grant St Casper Wyo
Carper Drlg Co Inc Box 905 Hobbs N Mex
Cecil Chisler & Son Fairview Rt 2 Fairview W Va
Choate & Hitt Box 310 Cisco Tex
Clock Drlg Co Box 498 Great Bend Kans
Harry L Cullet Purefoy Hotel Talladega Ala
Cummins Drlg Co Altamont Ill

D

Dee Drlg Co 407 S Pettit Hominy Okla
W L Dillier Box 341 Casey Ill

E

E & H Drlg Co Box 1058 Graham Tex
Eastland Drlg Co 806 Continental Life Bldg Ft Worth 2 Tex
Eatmon Drlg Co Box 535 Kimball Neb

F

Fairman Drlg Co Hammersley Fork Pa

G

Goll Graves & Mechling Inc 205 Bearinger Bldg Saginaw Mich
Graham-Michaelis Oil Co 211 N Broadway Wichita 2 Kans
Gulf Coast Western Oil Co 1816 Republic Bldg Oklahoma City Okla

H

Highland Oil Box 263 Jasper Ind
C F Hills Drlg Co Box 2158 Pampa Tex
C L Hinds Drlg Contr Box 22 Liberal Kans
Chas E Hipp Box 26 Graham Tex
Holt Bros Drlg Co Box 236 Pampa Tex
R L Horn & Son Drlg Co Pawnee Okla

J

J M C Drlg Interests 6282 E Marshall Tulsa Okla
Charles M Jameson Box 532 Vernal Utah

K

Kay Drlg Co Inc Box 1 Liberal Kans
Kersey & Co Box 305 Artesia N M
Keyes Drlg Co Box 1108 Roswell N M
Kirby Oil Ind Inc 5107 Center St Omaha 6 Neb
Earl Knox Drlg Co Box 125 Coweta Okla

L

Ralph G Ladd Box 5 Haskell Okla
J W Lawrence Box 942 Conrad Montana
Lee Drlg Co Box 637 Rangley Colo
H J Lininger Box 37 Upper Sandusky O
Lin-Mour Drlg Co 1112 Oil & Gas Bldg Wichita Falls Tex
Lohmann-Johnson Drlg Co Inc 320 Indiana Bk Bldg Evansville Ind

M

M-H-O Drlg Co Box 297 Cut Bank Montana
M L (Mike) Marrs Drlg Co Box 985 Drumright Okla
W H McGarr Industries Box 472 Eagle Pass Tex
Mobile Drlg Co 705 4th Natl Bk Bldg Wichita 2 Kans
Mora Drlg Co 800 Midstates Bldg Tulsa Okla
Moran Bros Inc 1200 Oil & Gas Bldg Wichita Falls Tex
C V Morgan First Natl Bk Bldg Olney Tex
Dave Morgan Drlg Co Box 820 Blackwell Okla
Morrison Drlg Co Inc Box 583 Casper Wyo
Murphy & McKernan Box 169 Pampa Tex
C L (Cluke) Myers Drlg Co Inc 317 E Ninth St Wewoka Okla

N

Needham Drlg Co Box 1285 Artesia N Mex
Nemaha Oil Co Mercantile Bk Bldg Dallas Tex

O

Oien Oil Corp Box 2235 Cut Bank Mont
Oney Drlg Co Box 425 Graham Tex

P

Payne Bros Drlg Co Box 15 Lawrenceville Ill
Perrine & Perrine Drlg Contr Box 87 Salem Ill
Louis Pitcock Drlg Co Box 749 Graham Tex
C C Pollard & Son Box 65 Ft Stockton Tex
Fred Pool Drlg Co 3106 Lockheed Midland Tex
Princeton Mining Co 111 N Seventh St Terre Haute Ind

R

Ramey Well Serv Suite 401-P Robertson Bldg Wichita Falls Tex
Rex & Morris Drlg Co Box 334 El Dorado Kans
Robinson Bros Oil Producers Box 430 Borger Tex
Rox Drlg Co Box 540 Ft Smith Ark
J W Rudy Box 684 Clay City Ill
Russell & Russell Drlg Co 621 Lindsay St Gainesville Tex

S

Sage Drlg Co Inc 1100 Bitting Bldg Wichita 2 Kans
Seibolt Drlg Co Box 847 Cushing Okla
SeRoBee Drlg Co Inc 412 Union Natl Bk Bldg Wichita Kans
Shields Oil Producers Shields Bldg Russell Kans
Shulman Bros Box 191 Vandalia Ill
H H Simons Co 416 E 9th St Colorado City Tex
Don Slape Drlg Co Box 432 Olney Ill
Smallwood & Son Drlg Co 3657 E Kiest Blvd Dallas Tex
James Smith Drlg Contr Box 33 Mertzon Tex
K Smith Cable Tools 1801 Van Buren Great Bend Kans
Ray Smith Drlg Co 305 Simons Bldg Dallas Tex
H J Steward Box 1031 Taylor Tex
Straight & Kane Box 919 Bartlesville Okla
C W Strotman Drlg Co 620 S 30th St Mattoon Ill
Sutton Drlg Co Box 6446 San Antonio Tex

T

Temple Drlg Co Inc 320 Indiana Bk Bldg Evansville Ind
Tolson Drlg Co 213 Triangle Bldg Pawhuska Okla
Triple S Drlg Co Route 1 Box 393 Broken Arrow Okla
Troup & Suttles Inc Box 551 Holdenville Okla

V

V S & S Drlg Co 1004 Ridgley Bldg Springfield Ill
Veeder Supply & Development Co Box 201 Cherryvale Kans

W

J H Wagner Drlg Co Box 751 Eldorado Kans
Art West Drlg Co 205 O'Michael Bldg Odessa Tex
Western Drlg Co Inc 902 Lubbock Natl Bk Bldg Lubbock Tex
Wilbanks & Rutter Drlg Co 2200 Scurry St Big Spring Tex

Y

S P Yates Drlg Co 311 Carper Bldg Artesia N M
Wesley C Young Drlg Co Box 5733 Sonora Tex

U. S. Contract CABLE TOOL Drilling Rigs

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
ALABAMA						
Harry L Cullet	1	gas-gaso-btne	125	3000	3500	Crdwll H
TALLADEGA COUNTY						
Harry L Cullet	2	gas-gaso-btne	150	5000	5500	Star Spdr
	3	gas-gaso-btne	250	7000	7500	Special
ARKANSAS						
CRAWFORD COUNTY						
Rox Drlg Co	7	gas-btne	250	6500	–	Natl Mach
FRANKLIN COUNTY						
Rox Drlg Co	1	gas-btne	250	8500	–	Standard
	2	gas-btne	165	6500	–	Natl Mach
	4	gas-btne	165	6500	–	Natl Mach
	5	gas-btne	165	6500	–	Natl Mach
	6	gas-btne	165	6500	–	Natl Mach
POPE COUNTY						
Rox Drlg Co	3	gas-btne	165	6500	–	Natl Mach
COLORADO						
ARCHULETA COUNTY						
Western Drlg Co Inc	10	btne	185	–	–	B Erie 48-L
MESA COUNTY						
Western Drlg Co Inc	8	btne	185	–	–	B Erie 48-L
RIO BLANCA COUNTY						
Lee Drlg Co	1	dsl	200	7000	8000	Crdwll RL
ROUTT COUNTY						
Western Drlg Co Inc	5	btne	185	–	–	B Erie 48-L
	7	dsl	185	–	–	B Erie 48L
WASHINGTON COUNTY						
Eatmon Drlg Co	3	prop	–	–	6000	Wlkr-Nr
IDAHO						
BANNOCK COUNTY						
Charles M Jameson	1	gas-gaso	–	3500	–	B Erie 36-L
ILLINOIS						
CHRISTIAN COUNTY						
C W Stratman Drlg Co	3	gas	145	3600	4500	Crdwll H
V S & S Drlg Co	1	gas	–	–	2000	Wichtex
CLAY COUNTY						
Shulman Bros	1	gas-gaso	–	4000	–	Crdwll H
CLINTON COUNTY						
Shulman Bros	2	gas-gaso	–	4000	–	Crdwll H
COLES COUNTY						
Cummins Drlg Co	C-5	gas-gaso	78	2500	3500	B Erie 28-L
	C-6	gas-gaso	78	2500	3500	B Erie 28-L
EFFINGHAM COUNTY						
Cummins Drlg Co	C-7	gas-gaso	45	1000	1250	B Erie 22-W
FAYETTE COUNTY						
Cummins Drlg Co	C-1	gas-gaso	65	1500	2000	B Erie 24-L
	C-2	gas-gaso	65	1500	2000	B Erie 24-L
	C-3	gas-gaso	65	1500	2000	B Erie 60-L
	C-4	gas-gaso	65	1500	2000	B Erie 60-L
GALLATIN COUNTY						
V S & S Drlg Co	3	gas	–	3500	3500	Cooper
KENKAKEE COUNTY						
Moran Bros Inc	5	LPG-gas	175	4500	7000	B Erie 36-L
LAWRENCE COUNTY						
Payne Bros Drlg Co	1	dsl	150	3000	4000	B Erie 36-L
	2	dsl	150	3000	4000	B Erie 36-L
C W Stratman Drlg Co	4	gas	175	3500	4500	Crdwll K
RICHLAND COUNTY						
J W Rudy	3	btn	130	–	4000	Crdwll K
Don Slape Drlg Co	1	btne	–	–	–	Crdwll K
WABASH COUNTY						
C W Stratman Drlg Co	1	gas	145	3600	4500	Crdwll H
INDIANA						
GIBSON COUNTY						
Highland Oil	1	dsl	–	2000	–	B Erie 24-L
	2	dsl	–	3000	–	B Erie 28-L
Princeton Mining Co	1	gas	175	–	3500	Crdwll Mobil
C W Stratman Drlg Co	2	gas	175	3500	4000	B Erie 36-L
PIKE COUNTY						
W L Dillier	1	gas	65	1500	2000	B Erie 60-L
POSEY COUNTY						
Lohmann-Johnson Drlg Co Inc	2	btne	–	4500	4500	Crdwll
IOWA						
DALLAS COUNTY						
Kirby Oil Ind Inc	–	gas-gaso	145	–	2	Crdwll RL
	–	gas-gaso	145	–	–	B Erie 28-L
KANSAS						
BARBER COUNTY						
Mobile Drlg Co	5	gas	100	–	5500	Crdwll
BARTON COUNTY						
Sage Drlg Co Inc	1	LPG	150	5000	5000	B Erie
Shields Oil Producers	3	dsl	160	3500	7000	Crdwll RL
BUTLER COUNTY						
R P Baker Drlg Co	1	dsl	128	4000	–	Natl 3-A-6
Butler County Drlg Co	1	dsl	150	3600	5000	Natl 3-A-6
Rex & Morris Drlg Co	1	dsl	–	3500	4500	B Erie 36-L
J H Wagner Drlg Co	2	gas-LPG	145	3500	4500	B Erie 36-L
	3	gas-LPG	145	3500	4500	B Erie 36-L
CHAUTAUGUA COUNTY						
Bennett Drlg Co	3	LPG	–	2750	3250	B Erie 28-L
Straight & Kane	1	LPG	–	–	–	B Erie 28-L
GRAHAM COUNTY						
Bill's Drlg Serv	1	dsl	–	4500	4500	Crdwll Spddr Rl
GRANT COUNTY						
C L Hinds Drlg Contr	1	LPG	145	4000	–	Wlkr-Nr S-43
	1	LPG	145	6000	–	Wlkr-Nr C-34
HARPER COUNTY						
Butler County Drlg Co	3	LPG	145	4500	5000	Wlkr-Nr S-43
KINGMAN COUNTY						
Mobile Drlg Co	2	gas	100	–	5000	Crdwll
	3	gas	100	–	5500	Crdwll
McPHERSON COUNTY						
Mobile Drlg Co	1	gas	75	–	3600	Crdwll
MARION COUNTY						
SeRaBee Drlg Co Inc	1	btne	–	4000	–	Crdwll RL
	2	btne	–	4000	–	Crdwll RL
MONTGOMERY COUNTY						
Veeder Supply & Dev Co	BE 2	dsl	120	3500	4500	B Erie
MORTON COUNTY						
Graham-Michaelis Drlg Co	3	dsl	150	3500	6000	B Erie 36
ROOKS COUNTY						
K Smith Cable Tools	1	gas-prop	145	3000	5000	Wlkr-Nr
RUSSELL COUNTY						
Clock Drlg Co	1	btne	145	7000	–	Frnks 7000
Shields Oil Producers	2	dsl	160	3500	7000	B Erie 48-L
STAFFORD COUNTY						
Clock Drlg Co	2	btne	145	8000	–	Crdwll B-J
	3	btne	200	6000	–	B Erie 36-L
Mobile Drlg Co	4	gas	100	–	5500	Crdwll
SUMNER COUNTY						
Butler County Drlg Co	2	LPG	140	3500	4500	Wlkr-Nr S-43
WOODSON COUNTY						
C H Barker	1	gaso	145	3000	–	Wlkr-Nr 32
KENTUCKY						
DAVIESS COUNTY						
Payne Bros Drlg Co	3	dsl	150	3000	4000	B Erie 36-L
GREEN COUNTY						
Bennett Drlg Co	6	LPG	–	1750	2250	B Erie 24-L
HENDERSON COUNTY						
Temple Drlg Co Inc	1	btne	–	1800	1800	B-Erie 24-L
MARSHALL COUNTY						
Perrine & Perrine Drlg Contr	2	btne	145	–	6000	B Erie 36-L
MICHIGAN						
MACOMB COUNTY						
Bernhardt Drlg Co	2	dsl-btne	175	6500	–	B Erie 36
MONROE COUNTY						
Bernhardt Drlg Co	1	btne	175	5000	–	B Erie 36
ST. CLAIR COUNTY						
Goll Graves & Mechling Inc	1	LPG	–	5000	6000	B Erie 36-L
	2	LPG	–	5000	6000	B Erie 36-L
MONTANA						
GLACIER COUNTY						
M-H-O-Drlg Co	4	gas-btne	165	3500	5000	B Erie 36-L
	6	dsl	140	3000	4500	B Erie 36-L
	7	dsl	220	6000	8000	B Erie 48-L
Oien Oil Corp	1	dsl	150	3000	5000	B Erie 36-L
	2	gas-LPG	150	3000	5000	B Erie 36-L
LIBERTY COUNTY						
B & B Drlg Co (Montana)	1	gas	145	3500	–	B Erie 36L
TETON COUNTY						
J W Lawrence	1	gas-gaso	125	3500	–	Natl
	2	gas-gaso	175	5000	–	B Erie
NEBRASKA						
CHEYENNE COUNTY						
Eatmon Drlg Co	2	prop	–	–	8000	Crdwll RL
KIMBALL COUNTY						
Eatmon Drlg Co	1	prop	–	–	8000	Crdwll RL
RICHARDSON COUNTY						
Nemaha Oil Co	1	gas	150	–	4500	Wichtex C-60
NEVADA						
CHURCHILL COUNTY						
Barry Well Drlg	3	gaso	85	–	500	Custom

LEE C. MOORE

DRILLING STRUCTURES

DESIGNED

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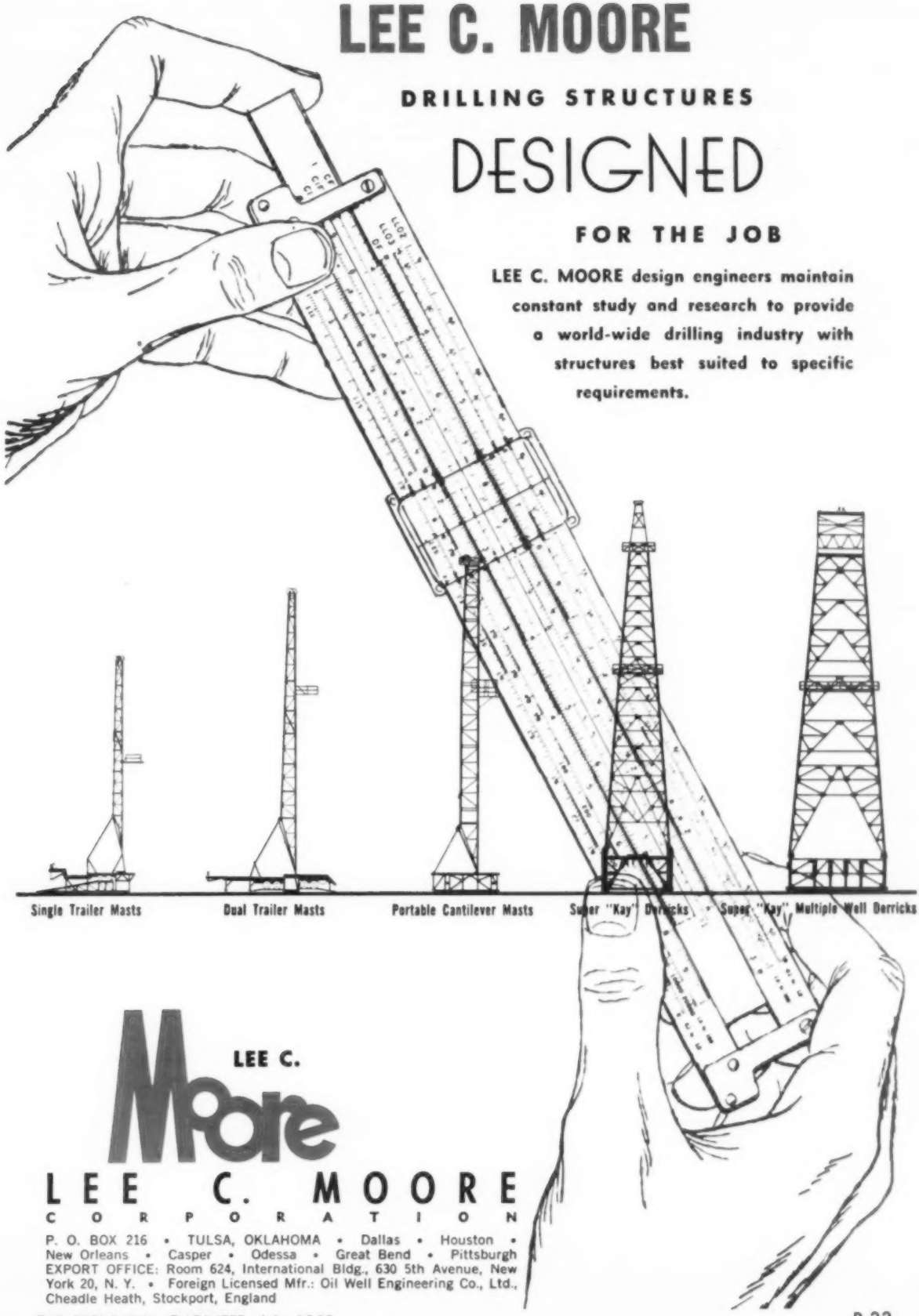
LEE C. MOORE design engineers maintain constant study and research to provide a world-wide drilling industry with structures best suited to specific requirements.



LEE C. Moore

LEE C. MOORE CORPORATION

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EXPORT OFFICE: Room 624, International Bldg., 630 5th Avenue, New York 20, N. Y. • Foreign Licensed Mfr.: Oil Well Engineering Co., Ltd., Cheadle Heath, Stockport, England

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
NEW MEXICO						
CHAVES COUNTY						
Keyes Drlg Co	4	LPG	53	1500	2500	B Erie 24-L
EDDY COUNTY						
Carper Drlg Co Inc	5-C	gas-LPG	125	4000	4500	B Erie 36-L
Kersey & Co	1	gas-gaso	185	5000	5000	Natl 3
	2	gas-gaso	120	3000	3500	Wich Spddr 55
	3	gas-gaso	120	4000	4500	Wich Spddr 61
	4	gas-gaso	120	4000	4500	Natl 3
Needham Drlg Co	1	LPG	180	5000	–	Wich Spdr 66
	2	LPG	186	5000	–	Wich Spdr 66
	3	–	165	4500	–	Wich Spdr 61
S P Yates Drlg Co	3	LPG	150	3500	–	Wichita 55
	4	LPG	130	3000	–	Ft Wrth Spr J
	5	LPG	180	6000	–	Ft Wrth Jumbo J
	6	LPG	180	6000	–	Ft Wrth Jumbo J
LEA COUNTY						
Carper Drlg Co Inc	6-C	gas-LPG	145	6000	7000	Wlkr-Nr S-55
Art West Drlg Co	3	gas	145	–	6000	Crdwll KL
	7	gas	145	–	8000	Crdwll RL
RIO ARRIBA COUNTY						
C L (Cluke) Myers Drlg Co Inc	2	gas-btne	145	4500	7500	Wlsn Mogul
OHIO						
WYANDOT COUNTY						
H J Lininger	1	gas-gaso	78	2500	–	Beth Cyclone
	2	dsl	175	3500	–	L C Moore
	3	gas-gaso	65	1800	–	Beth Cyclone
OKLAHOMA						
BEAVER COUNTY						
Graham-Michaelis Drlg Co	1	dsl	175	3000	8000	Crdwll
	2	dsl	175	3000	8000	Crdwll
Kay Drlg Co Inc	2	btne	219	9000	–	B Erie 48
CREEK COUNTY						
Duke Anderson Drlg Co	A	btne-gas	140	–	4500	B Erie 36L
	1	btne-gas	145	–	9000	Crdwll R
	2	btne-gas	145	–	9000	Crdwll R
Bennett Drlg Co	2	LPG	–	3500	4000	Star 45
M L (Mike) Marrs Drlg Co Inc	4	LPG	145	3500	5000	B Erie 36-L
GRANT COUNTY						
Seibold Drlg Co	1	gas-btne	165	7000	9000	Wlkr-Nr
HUGHES COUNTY						
Troup & Suttles Inc	1	gas-gaso	145	–	9000	Wlkr-Nr 33
KAY COUNTY						
Dave Morgan Drlg Co	–	LPG-gas	145	–	6500	Crdwll RL
LOGAN COUNTY						
Bodard Drlg Co	2	gas	225	7000	7000	Wlkr-Nr C-34
MUSKOGEE COUNTY						
Ralph G Ladd	1	gas-gaso	65	1750	2500	Star Spddr K
NOBLE COUNTY						
Duke Anderson Drlg Co	–	gas-btne	145	–	6000	Wlkr-Nr C-34
NOWATA COUNTY						
Bennett Drlg Co	10	LPG	–	2000	2500	B Erie 60-L
OKMULGEE COUNTY						
Earl Knox Drlg Co	28L	LPG	90	2500	3000	B Erie 28-L
Smallwood & Son Drlg Co	2	btne	–	3500	5600	B Erie 36-L
OSAGE COUNTY						
Bennett Drlg Co	8	LPG	–	2750	3250	B Erie 28-L
Dee Drlg Co	1	gas-btne	145	3500	–	B Erie 36-L
R L Horn & Sons Drlg Co	1	dsl	60	1600	2000	Star 72
M L (Mike) Marrs Drlg Co Inc	2	LPG	145	3500	5000	B Erie 36-L
Tolson Drlg Co	1	LPG	145	4000	5000	Wlkr-Nr S-33
PAWNEE COUNTY						
M L (Mike) Marrs Drlg Co Inc	1	LPG	145	3500	4500	B Erie 36-L
PAYNE COUNTY						
Duke Anderson Drlg Co	3	btne-gas	145	–	9000	Crdwll R
POTTAWATOMIE COUNTY						
Mora Drlg Co	6	dsl	250	5000	–	Wlsn Mogul
SEMINOLE COUNTY						
Gulf Coast Western Oil Co	1	gas	145	5000	6500	Wlkr-Nr C-34
C L (Cluke) Myers Drlg Co Inc	1	gas-btne	145	6500	11000	Crdwll RL
TEXAS COUNTY						
C L Hinds Drlg Contr	1	LPG	200	8000	–	Wlkr-Nr S-33 Super
Kay Drlg Co Inc	1	btne	145	8000	–	Crdwll RL
TULSA COUNTY						
Bar-Lee Drlg Co	1	LPG	120	3000	3500	Wlkr-Nr 32
J M Corbett	1	gas	–	5000	6500	Ft Wrth
J M C Drlg Interests	2	gas	–	1500	–	Keystone
Mora Drlg Co	1	dsl	250	5000	–	Wlsn Mogul
	4	gas	300	7000	–	Wlsn Giant
	7	gas	200	3500	–	Natl T-12
Triple S Drlg Co	–	btne	120	2500	3500	B Erie 60-L
WASHINGTON COUNTY						
Bartles-Johnstone Oil Co	–	gas-gaso-btne	70	1800	–	Ft Wrth H
Bennett Drlg Co	5	LPG	–	2750	3250	B Erie 28-L
Straight & Kane	2	LPG	–	–	–	B Erie 28-L
PENNSYLVANIA						
CLEARFIELD COUNTY						
Fairman Drlg Co	2	dsl	225	7500	8000	B Erie Spddr 48-L
	3	gas	225	7500	8000	B Erie Spddr 48-L
	4	gas	225	7500	8000	B Erie Spddr 48-L
ELK COUNTY						
Fairman Drlg Co	5	dsl	170	5000	6000	B Erie Spddr 36-L
JEFFERSON COUNTY						
Fairman Drlg Co	1	dsl	225	7500	8000	B Erie Spddr 48-L
TEXAS						
ARCHER COUNTY						
Baggett Drlg Co	1	–	145	8000	–	Wlkr-Nr 37
	2	–	145	7000	–	Wlkr-Nr 34
	3	–	190	7000	–	Wlkr-Nr C27
	4	–	190	7000	–	Wlkr-Nr C27
BAYLOR COUNTY						
Lin-Mour Drlg Co	3	btne	100	5000	–	Wlkr-Nr C-33
COLEMAN COUNTY						
W H McGarr Ind	2	gas-LPG	100	2500	2500	Ft Wrth Spr D
COMANCHE COUNTY						
Choate & Hitt	1	LPG	160	4000	5000	Ft Wrth S J
COOKE COUNTY						
Chas E Hipp Co	15	btne	145	4000	5000	B Erie 36L
	16	btne	145	4000	5000	B Erie 36L
	17	btne	225	6000	9000	B Erie 48L
Russell & Russell Drlg & Prod Co	1	gaso	90	2500	2500	Ft Wrth Spr H
CROCKETT COUNTY						
Fred Pool Drlg Co	–	–	–	4500	–	Ft Wrth Spddr J 37
ECTOR COUNTY						
Eastland Drlg Co	6	gas	125	4500	6000	B Erie
Art West Drlg Co	9	gas	185	–	9000	Wlsn Giant
GRAY COUNTY						
C F Hills Drlg Co	2	gas-btne	145	5000	9000	Wlkr-Nr S-33
Murphy & McKernan	1	gas-gaso	145	4500	5500	B Erie 36-L
	2	gas-gaso	145	4500	5500	B Erie 36-L
HUTCHINSON COUNTY						
Graham-Michaelis Drlg Co	4	dsl	175	–	8000	Crdwll RL
C F Hills Drlg Co	3	gas-btne	145	6000	7800	Wlkr-Nr C-34
Holt Bros Drlg Co	1	LPG	145	3500	6000	B Erie 36-L
Moran Bros Inc	3	LPG-gas	175	4500	7000	B Erie 36-L
Robinson Bros Oil Producers	1	gas	200	4500	5000	B Erie 48-L
IRION COUNTY						
James Smith Drlg Contr	1	gaso-LPG	145	3500	4000	B Erie 36-L Spdr
La SALLE COUNTY						
Sutton Drlg Co	10	dsl	600	11000	–	Beth Twister S-55
LOVING COUNTY						
Ray Smith Drlg Co	S-32	gas-LPG	140	3000	4000	Wlkr-Nr S-32
	S-33	gas-LPG	145	5000	6000	Wlkr-Nr S-33
	S-43	gas-LPG	140	3000	4000	Wlkr-Nr S-43
Western Drlg Co Inc	2	btne	145	–	–	B Erie 36-L
LUBBOCK COUNTY						
Western Drlg Co Inc	3	btne	145	–	–	B Erie 36-L
MAVERICK COUNTY						
W H McGarr Ind	1	gas-LPG	120	4500	4500	Wich 61
MITCHELL COUNTY						
H H Simons Co	1	btne	160	5000	–	Ft Wrth J Special
PALO PINTO COUNTY						
E H & Drlg Co	2	gas-btne	225	4500	6000	M-CSCO U-34
Oney Drlg Co	3	gas	210	6500	–	Wichita
PECOS COUNTY						
Fred Pool Drlg Co	–	–	–	4000	–	Ft Wrth Spddr F 37
REAGAN COUNTY						
Wilbanks & Rutter Drlg Co	2	gas	–	–	–	–
STEPHENS COUNTY						
Choate & Hitt	1	LPG	185	5000	6500	Ft Wrth J J
E & H Drlg Co	1	gas-btne	550	7500	10000	M-CSCO U-15
SUTTON COUNTY						
Wesley C Young Drlg Co	–	LPG	145	5000	5000	B Erie 36-L
	–	LPG	100	2500	3500	B Erie 28-L
	–	LPG	40	1000	2000	B Erie 22-W
TRAVIS COUNTY						
C & S Drlg Co	1	gaso	120	2000	2000	Super D
	2	gaso	120	1800	1800	Axtel 10
H J Steward	1	gaso	102	2000	2000	Ft Wrth D
UPTON COUNTY						
Brown & Thorp Drlg Co	2	LPG	135	5500	–	Wichita 66
	3	LPG	180	4000	–	Ft Wrth F-37
	4	LPG	135	4000	–	Ft Wrth F
	5	LPG	135	4000	–	Ft Wrth D
	6	LPG	180	4000	–	Ft Wrth F
	8	LPG	135	3500	–	Ft Wrth D
	9	LPG	135	3500	–	Ft Wrth D
	10	LPG	135	3500	–	Wichita 55
	11	LPG	135	3500	–	Ft Wrth D
WARD COUNTY						
C C Pollard & Son	–	dsl	150	5000	6000	Wich 66 Spddr
	–	gas	150	4000	5000	Wich 61 Spddr
Art West Drlg Co	5	gas	185	–	8000	Crdwll RL
	6	gas	145	–	8000	Crdwll RL
	8	gas	145	–	8000	Crdwll RL
	10	dsl	125	–	8000	Crdwll RL
WICHITA COUNTY						
Ashton Well Serv	1	gas	65	–	3000	Wlkr-Nr C-31
Chas E Hipp Co	14	btne	145	4000	5000	B Erie 36L
Lin-Mour Drlg Co	2	gas	125	–	6500	Wlkr-Nr C-34
Ramey Well Service	1	LPG	140	–	8000	Wichtex E 75
	2	LPG	140	–	8000	Wichtex E75
	3	LPG	332	5000	–	Wichtex C-60

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
YOAKUM COUNTY						
Western Drlg Co Inc	4	btne	185	–	–	B Erie 48L
YOUNG COUNTY						
Chas E Hipp Company	11	btne	225	6000	9000	B Erie 48L
	12	btne	145	4000	5000	B Erie 36L
	18	btne	225	6000	9000	B Erie 48L
	19	btne	225	5000	9000	B Erie 48L
C V Morgan	1	gas-gaso	145	3000	–	B Erie 36-L
Oney Drlg Co	1	gas	165	5500	–	Wichita
Louis Pitcock Drlg Co	3	dsl	225	6000	7000	Wich 66
WEST VIRGINIA						
LOGAN COUNTY						
Allen Drlg Co	2	gas	145	5000		6000 B Erie Spddr 36-L
	3	gas	128	5000		6000 B Erie Spddr 36-L
	7	gas	175	3500		5000 Natl Mach 2
MARSHALL COUNTY						
Cecil Chisler & Son	1	gas	78	3000		3000 B Erie Spddr 28-L
	2	gas	145	4000		5000 B Erie Spddr 36-L
	3	gas	78	3000		3000 B Erie Spddr 28-L
WYOMING						
CONVERSE COUNTY						
Morrison Drlg Co Inc (Wyo)	3	btne	185	5500		8000 Crdwll
JOHNSON COUNTY						
Capitol Drlg & Serv Co	2	–	135	2500		3000 B Erie 28-L
NATRONA COUNTY						
Capitol Drlg & Serv Co	1	–	145	3500		4000 B Erie 36-L
Morrison Drlg Co Inc (Wyo)	1	btne	145	4500		6000 Crdwll
	2	btne	185	5500		8000 Crdwll

Canadian Cable Tool Drilling Contractors

G Bennett Drlg 1315 1st St W Calgary Alberta Canada
Patterson & Culver Box 92 Dunnville Ontario Canada

Canadian Cable Tool Rigs

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
CANADA						
ALBERTA PROVINCE						
G Bennett Drlg	–	gas	100	–	–	Failing
	–	–	–	–	–	Sewell
ONTARIO PROVINCE						
LAKE ERIE (NORTH SHORE)						
Patterson & Culver	2	dsl	80	1500		2000 B Erie 24-L
	3	dsl	80	1500		2000 B Erie 24-L
NORFOLK						
Patterson & Culver	1	gas	80	2500		3500 B Erie 28-L

U. S. Cable Tool Servicing Rigs

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
COLORADO						
AULT						
Prairie Drlg Co	2	gas	190	–	10000	Crdwll RS
STERLING						
Signal Oilfield Serv Inc	4	dsl	125	–	7500	Crdwll RL
	5	dsl	125	–	7500	Crdwll RL
	11	gas	125	–	7500	Crdwll RL
ILLINOIS						
LAWRENCEVILLE						
Payne Bros Drlg Co	1	dsl	150	3000		4000 B Erie 36-L
	2	dsl	150	3000		4000 B Erie 36-L
	3	dsl	150	3000		4000 B Erie 36-L
KANSAS						
EL DORADO						
J H Wagner Drlg Co	2	gas-LPG	145	3500		4500 B Erie 36-L
	3	gas-LPG	145	3500		4500 B Erie 36-L
OLNEY						
F M Johnson Well Serv	1	LPG	135	–	2500	Johnson Sp 30
	2	LPG	135	–	3500	Clark 30
	3	LPG	135	–	3500	Clark 30
	4	LPG	145	–	4500	Clark 30 Sp
	5	LPG	145	–	5000	Clark 30 Sp
STINNETT						
Texas Well Serv Co	2	btne	145	5000	5000	B Erie 36-L
	3	btne	145	5000	5000	B Erie 36-L
	4	btne	140	5000	5000	Wichtex
WICHITA FALLS						
Deep Well Serv Co	2	LPG	140	–	6500	Wichtex C-65
McAlister Well Serv	32	LPG	185	–	7000	Wlkr-Nr C-34
WICKETT						
Art West Drlg Co	5	LPG	185	–	8500	Crdwll RL
	6	gas	145	–	8000	Crdwll RL
	8	gas	145	–	8000	Crdwll RL
	10	dsl	125	–	8000	Crdwll RL
WYOMING						
CASPER						
Morrison Drlg Co Inc (Wyo)	1	btne	145	4500	6000	Crdwll
	2	btne	185	5500	8000	Crdwll
	3	btne	185	5500	8000	Crdwll
GREAT BEND						
Signal Oilfield Serv Inc	1	dsl	125	–	7500	Crdwll RL
	7	gas	125	–	5000	Wlkr-Nr
	9	dsl	125	–	7500	Crdwll RL
NEW MEXICO						
FARMINGTON						
Signal Oilfield Serv Inc	12	gas	125	–	7500	Crdwll RL
	13	gas	125	–	7500	Crdwll RL
HOBBS						
Art West Drlg Co	3	LPG	145	–	5500	Crdwll RL
	7	LPG	145	–	8000	Crdwll RL
OHIO						
LOGAN						
R A Cooper Drlg Co Inc	1	gas	–	4000	4000	Natl 12
WYANDOT COUNTY						
H J Lininger	1	gas-gaso	78	2500	–	Beth Cyclone
	2	dsl	175	3500	–	L C Moore
	3	gas-gaso	65	1800	–	Beth Cyclone
OKLAHOMA						
DRUMWRIGHT						
M L (Mike) Morris Drlg Co	1	LPG	145	3500	4500	B Erie 36-L
	2	LPG	145	3500	5000	B Erie 36-L
	4	LPG	145	3500	5000	B Erie 36-L
GUYMON						
Bice Drlg Co	1	dsl	185	3000	4500	Wichtex E90
	11	btne	210	7000	10000	B Erie
PIKE CITY						
Line Oil Well Serv Co	1	gas-gaso-LPG	245	7500	10000	Crdwll RL
	5	gas-gaso-LPG	245	7500	10000	Crdwll RL
	6	gas-gaso-LPG	140	4500	5000	Crdwll K
SHIDLER						
Signal Oilfield Serv Inc	3	gas	125	–	7500	Crdwll RL
	8	gas	125	–	5000	Wlkr-Nr
TEXAS						
GRAHAM						
Louis Pitcock Drlg Co	21	gas-btne	125	5000	8000	Wichtex 46
GRAND FALLS						
Dick Hamm Drlg Co	1	btne	145	4500	7000	Wlkr-Nr S-33
	2	btne	140	–	3500	Wlkr-Nr C-33
	3	btne	140	4000	4000	B Erie 36-L
McCAMEY						
C N Adkisson Jr	1	LPG	100	2500	3000	B Erie 28-L
ODESSA						
Art West Drlg Co	9	LPG	185	–	9000	Wlsn Gnt

U. S. Well Servicing Contractors

A

A A A Well Serv Co Inc Box 9172 Shreveport La
A C Well Serv Box 356 Davenport Okla
Acme Well Serv Co Box 1331 Abilene Tex
Adams Prod Serv 2 Monte Vista Dr Bakersfield Calif
C N Adkisson Jr Box 875 McCamey Tex
Albright Well Serv Co Box 1192 Hobbs N M
Anderson Oilwell Serv Box 304 McPherson Kans
Ashworth Oil Well Serv Co Box 1109 Bay City Tex

B

B & B Well Serv Co Box 321 Salem Ill
B & G Well Serv 2011 S Main Winfield Kans
B L & B Well Serv Co 7003 N Clements St Gainesville Tex
B L & H Drlg Co Inc Box 567 Kilgore Tex
Ballard Well Service Pettus Tex
Barnard Well Serv Box 617 Madison Kan
Basin Well Serv Inc 2411 Rankin Hwy Midland Tex
Robert M Bass Drlg Contr Box 471 Kilgore Tex
Beall Well Serv Co 571 San Jacinto Bldg Houston 2 Tex
Beckman Inc Box 1524 Muskogee Okla
Bernhardt Drlg Co 2469 Grand River Detroit 1 Mich
Bice Drlg Co 1310 N Ellison Guymon Okla
M E Billings Well Serv Inc 928 E 15th St Casper Wyo
Bill's Well Serv Codell Kans
J W (Johnny) Birdwell Well Serv Box 201 Kamay Tex
Bivin & Smoot Drlg Co Box 147 Overton Tex
Black Gold Well Serv Box 1427 OCS Lafayette La
Blue Ridge Well Serv 2906 Holmes Rd Houston Tex
Bolin Well Serv Box 1412 Talco Tex
Booksh Well Serv Box 127 Grosse Tele La
Raymond K Brake Well Serv Box 285 Centralia Ill
D J Branyan Co Box 166 Cushing Okla
Brewer's B & H Well Serv Box 846 Snyder Tex
James P Brown Well Serv 1901 Florence St Kilgore Tex
Browning Well Serv Inc Henderson Kentucky

C

C V C Well Serv Co Box 169 Ft Morgan Colo
C & C Oil Field Serv Co Box 191 Oil City La
Calco Drlg Co 1113 Continental Bk Bldg Ft Worth Tex
California Prod Serv Inc 3252 Cherry Ave Long Beach 7 Cal
Camden Drlg Co Box 1418 Corpus Christi Tex
Capshaw Well Serv Co P. O. Box 1915 Casper Wyo
R L Carpenter Box 452 Sapulpa Okla
Carter Well Serv Box 178 Pettus Tex
Cash Const Co Box 86 Iraan Tex
G H Chambers Well Serv Box 597 Ripley Okla
Chase Well Serv Inc Box 325 Chase Kans
E L Cheeney Co Box 3 Raywood Tex
Chesnut Well Serv Co Box 1491 Odessa Tex
Chris Well Serv Co Ltd Box 37 Lindsay Okla
Christy Well Serv Co Box 516 Cortez Colo
Clarke Oil Well Serv Co Box 2315 Hobbs N M
Clarke & Dennis Well Serv Inc Box 5 Chapin Bldg Medicine Lodge Kan
Colorado Well Serv Inc Box 122 Rangely Colo
Columbia Drlg Co 1207 C & I Life Bldg Houston 2 Tex
R A Cooper Drlg Co Inc 711 Hulman Bldg Evansville 8 Ind
Copeland Well Serv Box 641 Russell Kan
Copeland & Fuller Well Serv Box 237 Kenedy Tex
Jess P Cross Drlg Contr 1216 Texas St Graham Tex
Crusader Drlg & Serv Inc Box 851 Springhill La
Paul Curtner Drlg Co Box 1032 Jacksboro Tex

D

D & G Drlg Co Box 1477 Levelland Tex
D & L Drlg & Serv Box 121 Perryton Tex
D & S Well Serv Co Box 102 Cody Wyo
Daniel & Langley Box 493 Smackover Ark
Deep Well Serv Co 3218 Cheryl St Wichita Falls Tex
Devonian Well Serv Box 2821 Odessa Tex
Dobson Well Serv Box 282 McLeansboro Ill
Robert B Doe — Oilfield Serv Rt 1 19030 James Rd Bakersfield Calif
Dollins Bro's Oil Well Serv Co Rt 2, Box 69 Breckenridge Tex
Drilling & Production Co 2907 L St Bakersfield Calif
E B Duncan Drlg & Well Serv Co Inc Box 4096 Shreveport La
Dyer Drlg Co Box 338 Casper, Wyoming

E

E & O Well Serv Co Inc Box 3066 Odessa Tex
Dood Emerson Well Serv & Gen Contrg Box 228 Sulphur Springs Tex
Exploration Drlg Co 607 Natl Bk of Tulsa Bldg Tulsa Okla

F

Forsan Well Serv Box A-584 Forsan Tex
French Drlg & Well Serv Box 190G Rt 1 Houston Tex
Fruge Well Service 1203 Center Vinton La

G

General Prod Serv Inc Box 442 Bakersfield Calif
Glenn Gillespie & Sons Box 907 Cushing Okla
Graham Bros Oil Well Serv Box 80 Brookhaven Miss
J P Graham Box 1307 Bay City Tex
Henry Gwaltney Drlg Co 19 NE Third St Washington Ind

H

H & W Oil Well Serv Box 435 Roundup Montana
H & W Well Serv Co Inc Box 141 Perryton Tex
John S Hagestad Drlg Co 3224 Gulf St Bakersfield Calif
Hale - Cook Serv Co Inc Box 5064 Abilene Tex
Dick Hamm Drlg Co Box 575 Grandfalls Tex
Harris Drlg Co Inc Box 868 Eunice La
Harrison Well Serv Box 21 Denver City Tex
Wm Hawkins Drlg Co 373 San Jacinto Bldg Houston 2 Tex
Hayden & Griffith Oil Well Serv Co 304 Calif Bldg Denver 2 Colo
J E Hillier Box 67 Pleasanton Tex
C L Hinds Drlg Contr Box 22 Liberal Kans
Hoffman Oil Well Serv Co Box 1167 Seminole Tex
W L Hopper Inc Box 171 Mentone Tex
Hydraulic Pipe Pulling Co Box 391 Kilgore Tex

I

Ivan Holt Well Serv Box 401 Russell Kans

J

J-B Swabbing Co Inc Box 1166 Kilgore Tex
J & M Oil Well Serv Inc Box 1716—Oil Ctr Sta Lafayette La
J & M Well Serv Box 445 Mission Tex
Neil Jackson & Sons Star Route East Artesia N M
Johnson Drlg & Serv Co Box 3 Magnolia Ark
F M Johnson Well Serv Box 613 Olney Tex

K

Kay Serv Co Box 123 Alvin Tex
Keeney Well Serv Co Box 44 Pleasanton Tex
Kent Oil Field Serv Inc Box 749 El Dorado Kans
Kent Well Serv Co Drawer 470 El Dorado Kans
C E Knight & Co Box 1688 Snyder Tex

L

L & W Well Serv MRH Box 120 Sulphur La
Lafourche Workover & Drlg Co Inc Box 8 Galliano La
Line Oil Well Serv Co Box 4447 Oklahoma City Okla
H J Lininger Box 37 Upper Sandusky Ohio
Locke Well Serv Box 312 Royalty Tex
Lunsford Drlg Co 505 Louisiana Bk Bldg Shreveport La

M

Mac Drlg Co Box 2972 Houston 1 Tex
Macrate Prod Co 3341 Cherry Ave Long Beach 7 Calif
Maddox Prod Co 2909 Junipero Ave Long Beach 6 Calif
Maddux Well Serv 199 N 10th St W Riverton Wyo
M L (Mike) Marrs Drlg Co Box 985 Drumright Okla
Maxwell Well Serv Co Box 475 New London Tex
J F McAdams Box 1716 Hobbs N M
McAlister Well Serv Box 2214 Wichita Falls Tex
McCalman Drlg Co Inc Box 602 Homer La
McDaniel Well Serv Box 456 Seminole Okla
McDonald Well Serv Co Box 2062 Abilene Tex
Jack Mercer Well Serv Box 509 Nocona Tex
Mobile Well Serv Box 36 Cayuga Tex
Mohawk Oil Well Serv Box 1454 Alice Tex
Moore Prod Serv 1843 East "D" St Wilmington Calif
Moose Well Serv Co Box 1325 Houston 1 Texas
E F Moran Inc 1805 Natl Bk of Tulsa Bldg Tulsa 3 Okla
Morrison Drlg Co Inc Box 583 Casper Wyo
Mumy Well Serv 7941 Patterson Rd Reed City Mich

N

Nichols & Freeman Well Serv Box 183 Grandfalls Tex

O

Oien Oil Corp Box 2235 Cut Bank Mont
Oil Well Serv Co 2405 Orange Ave Long Beach 6 Calif
Oliver Oil Well Serv 200 Berkley Ave Evansville Ind

P

P L & B Well Serv Corp 509 W T Waggoner Bldg Ft Worth 2 Tex
Payne Bros Drlg Co Box 15 Lawrenceville Ill
Perforaciones Delta C A Apartado 9138 Caracas Venezuela (Box 2012 Tyler Tex)
Pennant Well Serv Co Inc 981 Poli St Ventura Calif
J E Perkins Inc Box 3143 Odessa Tex
Permian Serv Co Inc Box 1477 Levelland Tex
Permian Well Serv Inc Box 37 Wink Tex
Pico Drlg Co Box 512 Breckenridge Tex
Louis Pitcock Drlg Co Box 749 Graham Tex
Pool Well Serv Co Box 1940 San Angelo Tex
Pool & Gerlich Drlg Co Box 1940 San Angelo Tex
Post & Brown Well Serv 208 S Main Stafford Kans
Potter Bros Box 1578 Kilgore Tex
W R (John) Potter Well Serv Box 14 Kamay Tex
Prairie Drlg Co Box 2068 Casper Wyo
Price-Caudle Well Serv Inc Box 453 Seminole Okla
Producers Well Serv Inc Box 98 Boling Tex
T M Pruett Drlg Contr Box 303 Centralia Ill

Q

Quad Drlg Co Box 974 Ardmore Okla

R

R O W S Co Inc Box 369 Russell Kans
R W I T Drlg Co Box 551 Haldenville Okla
R & R Well Serv Co Box 637 Rangely Colo
Ramey Well Serv 401-P Robertson Bldg Wichita Falls Tex
Rangely Well Serv Co Inc 321 C A Johnson Bldg Denver Colo
Rayburn Well Serv Inc 245 Catherine St Lockport La
Richey Drlg & Well Serv Box 834 Lafayette La
Rimrock-Tidelands Inc Box 896 New Orleans La
Rocket Well Serv 1706 Hill St Alvin Tex
Ed Rodgers Oil Well Serv Box 206 Holyrood Kans
Rutledge Drlg Co Box 2239 Santa Fe N Mex

S

S D & S Drlg Co Inc 325 Wilson Bldg Corpus Christi Tex
Savely Workover & Drlg Inc Box 407 Rosenberg Tex
Schaefer Well Serv Box 10 Victoria Tex
Seifried Well Serv 117 S Wyandotte Dewey Okla
Shebester Well Serv Box 338 Pauls Valley Okla
Shirer Well Serv Co Box 118 Hoisington Kans
Signal Oilfield Serv Inc 415 Petroleum Club Bldg Denver 2, Colo
Chas A Sipes Well Serv Box 382 Russell Kans
Sitton & Norton Drlg Co 406 Lubbock Natl Bk Bldg Lubbock Tex
Southwestern Well Serv Box 1116 Lovington N M
Spartan Well Serv 207 S & S Bldg Corpus Christi Tex
Spears Well Serv Inc Box 3187 Victoria Tex
J D Speer Box 327 Healdton Okla
J D Sprecher Box 299 Casper Wyo
Spur Well Serv Co Box 1325 Houston 1 Tex
Stewart's Casing Crew Box 14086 Houston 21 Tex
Stone Well Serv Box 386 Lolita Tex
Sunnyland Contracting Co Inc Box 388 Rayne La
Sutton Drlg Co Box 6446 San Antonio 9 Tex

T

Terminal Drlg & Prod Co 2975 Wilshire Blvd Suite 423 Los Angeles 5 Cal
Texas Well Serv Co Box 191 Borger Tex
Texas Workover & Oilwell Serv Co Box 32 Liberty Tex
Beuford Thompson Prod Maintainers 2412 Clarinda Wichita Falls Tex
Thornbrugh Well Serv Co Box 541 Natchez Miss
J R Todd Co Inc Box 168 Odessa Tex
Turner's Well Serv Box 149 Centralia Ill

U

Universal Oilwell Serv Inc Box 1092 Snyder Tex

V

Varner Oil Well Serv Box 253 Royalty Tex

W

WLB Drlg Co 6635 Chocolate Bayou Rd Houston 21 Tex
W M & W Well Serv Co Box 931 Alice Tex
Wade Drlg Co Inc 813 Gulf Bldg Tulsa Okla
Wagner & Wyant Drlg Co Inc 414 Petroleum Bldg Amarillo Tex
J H Wagner Drlg Co Box 751 El Dorado Kans
Delbert Wallace Well Serv Box 1262 Alice Tex
Dick Wegener Drlg Co 1820 First Natl Bldg Oklahoma City 2 Okla
Art West Drlg Co 307 O'Michael Bldg Odessa Tex
Williamson Well Serv Inc Box 3828 Odessa Tex
Winnsboro Well Service Co Box 102 Winnsboro Tex
Sam E Wood Box 546 Alvin Tex
Wyoming Well Serv Inc Box 350 Cody Wyo

Y

Young's Well Serv Inc Box 1336 Seminole Okla

U. S. Contract Well Servicing or Pulling Units

Contractor's Name	Rig No	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Pulling	Can Unit Also Drill?
ARKANSAS							
SMACKOVER							
Daniel & Langley	1	Wlsn Sr	Truck	1	–	4,000/2" 3,500/2½"	–
	2	Wlsn Sr	Truck	1	–	4,000/2" 3,500/2½"	–
	4	Wlsn Sr Spr	Truck	1	–	4,500/2"	No
CALIFORNIA							
BAKERSFIELD							
Adams Prod Serv	1	Wlsn Spr Trcr	Trailer	2	11,600	11,600/2" 8,500/2½" 6,000/3"	No
Robt B Doe Oilfield Serv	1	Crdwll H	Truck	1	4,500	5,000/2" 4,000/2½" 3,000/3"	No
	2	Crdwll HL	Truck	2	5,500	6,000/2" 5,000/2½" 4,000/3"	No
	3	Hopper	Truck	1	3,000	33,000/2" 2,000/2½" 1,500/3"	No
	4	Hopper	Truck	1	4,000	4,500/2" 3,500/2½" 2,500/3"	No
	5	Hopper	Truck	1	2,500	2,500/2" 1,500/2½" 1,000/3"	No
	6	Hopper IGFA	Truck	2	7,000	7,000/2" 6,000/2½" 5,000/3"	No
	7	Hopper IGFA	Truck	2	9,000	7,000/2" 6,000/2½" 5,000/3"	No
General Prod Serv Inc	3	Hopper G	Truck	2	6,000	6,000/2" 4,000/2½" 3,000/3"	No
	7	Ideco 30	Trailer	2	10,000	10,000/2" 7,500/2½" 6,000/3"	No
	9	Hopper GTA	Truck	2	10,000	10,000/2" 7,500/2½" 6,000/3"	No
	11	Hopper GTA	Truck	2	13,000	15,000/2" 12,000/2½" 10,000/3"	No
Oil Well Serv Co	1-A	Ideco 40	Trailer	2	13,000	13,000/2½" 10,000/3"	Yes
	2-A	Ideco 40	Trailer	2	13,000	13,000/2½" 10,000/3"	Yes
	11	Ideco 30	Trailer	2	10,000	10,000/2½" 8,000/3"	Yes
	12	Crdwll	Trailer	2	5,000	5,000/2½" 4,000/3"	
	15	Ideco 30	Trailer	2	13,000	13,000/2½" 8,000/3"	Yes
	60	Ideco H-25 CD	Self-Prop	2	11,500	10,000	Yes
COSTAIC							
Calif Prod Serv Inc	H-3	Hopper G	Truck	2	10,000	10,000	Yes
	H-10	Wgnr Mrhse	Truck	2	10,000	10,000	Yes
	M-7	Hopper 1G	Self Prop	2	8,000	8,000	No
	M-10	Hopper G	Self Prop	2	10,000	10,000	No

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Pulling	Can Unit Also Drill?
KERMAN							
Oil Well Serv Co	4-A	Ideco 30	Trailer	2	10,000	10,000/2½" 7,000/3"	Yes
	41	Ideco 30	Trailer	2	10,000	10,000/2½" 7,000/3"	–
	57	Ideco 35	Self Prop	2	13,000	13,000/2½" 8,000/3"	Yes
KERN							
Drlg & Prod Co	3	Ideco Rambler	Trailer	2	7,500	5,500/2" 5,000/2½" 4,500/3"	No
LONG BEACH							
Calif Prod Serv Inc	D-1	Hopper MTA	Trailer	2	15,000	15,000	Yes
	H-1	Crdwll "R"	Truck	2	10,000	10,000	Yes
	H-5	Hopper G	Truck	2	10,000	10,000	Yes
	H-9	Hopper 1G	Truck	2	8,000	8,000	Yes
	H-13	Wgnr Mrhse	Truck	2	10,000	10,000	Yes
	M-3	Hopper G	Trailer	2	10,000	10,000	Yes
	M-4	Hopper G	Trailer	2	10,000	10,000	Yes
	M-5	Ideco H-30	Trailer	2	10,000	10,000	Yes
	M-6	Hopper G	Trailer	2	10,000	10,000	Yes
	M-8	Wgnr Mrhse	Trailer	2	10,000	10,000	Yes
Macrate Prod Co	1	Ideco H-30	Trailer	2	10,000	12,000/2" 10,000/2½" 8,000/3"	Yes
	4	Wgnr-Mrhse	Trailer	2	10,000	12,000/2" 10,000/2½" 8,000/3"	No
	6	Wgnr-Mrhse	Trailer	2	10,000	12,000/2" 10,000/2½" 8,000/3"	No
	8	Wgnr-Mrhse	Trailer	2	12,000	14,000/2" 12,000/2½" 10,000/3"	Yes
Maddox Prod Co	1	Hopper	Truck	2	8,000	12,000/2" 9,000/2½" 7,000/3"	Yes
	2	Wlsn Spr	Trailer	2	10,000	17,000/2" 13,000/2½" 10,000/3"	Yes
	4	Wlsn Mogul	Trailer	2	13,000	17,000/2" 13,000/2½" 10,000/3"	Yes
Oil Well Serv Co	2	Wlsn Mogul	Truck	1	–	12,000/2½" 6,500/3"	Yes
	3	Ideco	Truck	2	13,000	13,000/2½" 7,000/3"	Yes
	5	Ideco	Truck	2	5,000	5,000/2½" 4,000/3"	Yes
	6	Crdwll	Truck	2	10,000	7,000/2½" 6,500/3"	–
	7	Ideco 30	Trailer	2	13,000	13,000/2½" 7,000/3"	Yes
	8-A	Ideco H-25 AD	Truck	2	11,500	10,000	Yes
	9	Ideco 30	Trailer	2	13,000	13,000/2½" 7,000/3"	Yes
	14	Ideco 30	Trailer	2	13,000	13,000/2½" 7,000/3"	Yes
VENTURA							
Calif Prod Serv Inc	D-2	Hopper MTA	Trailer	2	15,000	15,000	Yes
	D-3	Hopper MTA	Trailer	2	15,000	15,000	Yes
	D-4	Hopper MTA	Trailer	2	15,000	15,000	Yes
	D-5	"Oilwell" 66	Truck	2	15,000	15,000	Yes
	D-6	Emsco 500	Truck	2	15,000	15,000	Yes
	H-6	Hopper G	Truck	2	10,000	10,000	Yes
	M-9	Hopper G	Self Prop	2	10,000	10,000	No
Pennant Well Serv Co Inc	1	Wgnr-Mrhse 15-40	Trailer	2	–	–	–
	2	Wlsn Mogul	Trailer	–	–	–	Yes
Terminal Drlg & Prod Co	10	Ideco Rambler	Self Prop	2	13,000	11,500/2½"	Yes
	16	Wlsn	Self Prop	2	15,000	15,000/2½"	No
WILMINGTON							
Moore Prod Serv	1	Crdwll	Trailer	2	6,000	8,000/2" 6,000/2½" 5,000/3"	Yes
	2	Hopper Hoist	Truck	2	10,000	10,000/2" 10,000/2½" 9,000/3"	Yes
Terminal Drlg & Prod Co	11	Frnks 65-44	Self Prop	2	12,000	10,745/2½"	No
	13	Ideco H-30	Truck	2	11,000	9,420/2½"	No
	15	Ideco	Truck	2	12,000	10,600/2½"	Yes
	19	Ideco H-30	Truck	2	13,500	13,400/2½"	Yes
	22	Crdwll RL	Truck	2	10,000	10,000/2½"	Yes
	23	Crdwll HL	Truck	2	7,200	5,000/2½"	No
COLORADO							
CORTEZ							
Christy Well Serv Co	4	Crdwll K-203	Truck	2	12,000	12,000	No
	5	Crdwll AH	Truck	2	10,000	7,500	No
	11	Crdwll K-201	Truck	2	12,000	12,000	Yes
	12	Crdwll A-150	Truck	2	10,000	7,500	No
FT. MORGAN							
C V C Well Serv Co	1	Wichtex E-75	Truck	–	10,000	12,000/2"	No
RANGLEY							
Colorado Well Serv Inc	1	Frnks	Truck	2	–	–	–
	2	Frnks	Truck	2	–	–	–
	3	Frnks	Trailer	2	12,000	12,000/2"	Yes
	4	Frnks	Truck	2	12,000	12,000/2"	–
R & R Well Serv Co (Colo)	1	Frnks 658-TD	Truck	1	13,500	16,000/2" 12,500/2½" 10,000/3"	Yes
	2	Frnks 658-TD	Truck	1	13,500	16,000/2" 12,500/2½ 10,000/3"	Yes
	3	Frnks 658-TD	Truck	1	13,500	16,000/2" 12,500/2½" 10,000/3"	Yes
	4	Frnks 658-TD	Truck	1	13,500	16,000/2" 12,500/2½" 10,000/3"	Yes
	5	Frnks 658-TD	Truck	1	13,500	–	No
	6	Frnks 658-TD	Truck	1	13,500	16,000/2" 12,500/2½" 10,000/3"	Yes
	7	Frnks 658-TD	Truck	1	13,500	16,000/2" 12,500/2½" 10,000/3"	Yes
	8	Frnks 65TM	Truck	1	13,500	–	–
	9	Frnks 658 TD Expl	Truck	2	13,500	16,000/2" 12,500/2½" 10,000/3"	Yes
	10	Frnks 658-TD	Skid Mt'd	1	13,500	16,000/2" 12,500/2½" 10,000/3"	No
Rangely Well Serv Co Inc	1	Frnks 137-TD	Truck	–	15,000	15,000	Yes
STERLING							
Hayden & Griffith Oil Well Serv Co Inc	201	Frnks	Truck	2	12,000	12,000/2"	Yes
	203	Frnks	Truck	2	12,000	12,000/2"	Yes
Signal Oilfield Serv Inc	2	Frnks 658/44	Truck	2	10,000	–	Yes
ILLINOIS							
CENTRALIA							
Raymond K Brake Well Serv	1	Vickers	Truck	1	3,000	4,500	No
	2	Cooper	Truck	1	3,000	4,500	No
	3	Wilson	Truck	1	1,500	2,000	No
	4	Cooper	Truck	2	3,300	5,000	Yes
	5	Wilson	Truck	2	5,000	8,000	Yes
Turner's Well Serv	1	Wlsn Spr	Truck	–	–	8,000/2"	No
	2	Ideco	Truck	–	–	8,000/2"	No
	3	Crdwll	Truck	–	–	4,000/2"	No
	4	Wlsn	Truck	–	–	4,000/2"	No
	5	Wlsn	Truck	–	–	4,000/2"	No
	RC#1	Reverse Circ	Skid Mt'd	–	–	–	Yes
LAWRENCEVILLE							
Payne Bros Drlg Co	4	Crdwll	Truck	2	3,500	3,500	Yes
McLEANSBORO							
Browning Well Serv Inc	244	Wichtex C-60	Truck	2	3,500	4,500/2"	No
	246	Wlsn Sr	Truck	1	–	3,500/2"	No
	258	Wichtex	Truck	1	–	4,500/2"	No
	259	Crdwll Q	Truck	1	–	4,000/2"	No
Dobson Well Serv	3	Wlsn Sr	Truck	–	3,000	3,500/2½"	No
	5	–	Truck	1	3,000	–	No
	9	–	Truck	1	3,000	–	No
	15	Spdr	Truck	–	3,000	–	No
	23	–	Truck	2	3,000	–	No
SALEM							
B & B Well Serv Co	1	Wlsn	Truck	1	–	5,000/2"	No
	2	Crdwll Q	Truck	1	–	4,000/2"	No
	4	Wlsn	Truck	1	–	5,000/2"	No
	5	Wlsn	Truck	2	–	5,000/2"	No
	6	Wlsn	Truck	2	–	5,000/2"	No
INDIANA							
EVANSVILLE							
Oliver Oil Well Serv	–	Crdwll Q	Truck	–	–	3,000/2"	No
	–	Crdwll Q	Truck	–	–	3,000/2"	No
KANSAS							
ARKANSAS CITY							
Kent Well Serv Co	7	Cooper E	Truck	1	–	6,000/2"	No
	10	Cooper P-32-32	Truck	–	5,500	5,500/2"	No
	15	Cooper 42-36	Truck	–	6,500	6,500/2"	Yes
CHASE							
Chase Well Serv Inc	1	Frnks 4000TM	Truck	1	–	5,000/2" 4,500/2½" 3,600/3"	–
	2	Frnks TM-44	Truck	1	–	6,000/2" 5,500/2½" 4,500/3"	–
CODELL							
Bill's Well Serv	2	Frnks E-Tex	Truck	–	4,500	6,000/2"	No
	3	Frnks E-Tex	Truck	–	4,500	6,000/2"	No
	4	Frnks E-Tex	Truck	–	4,500	6,000/2"	No
COWLEY							
B & G Well Serv	52	Crdwll AH	Truck	1	5,000	5,000/2"	No
	94	Crdwll HS	Truck	1	5,000	5,000/2"	No
	107	Crdwll AH	Truck	2	5,000	5,000/2"	No
	114	Cooper	Truck	2	5,000	5,000/2"	No
EL DORADO							
Kent Well Serv Co	1	Cooper W	Truck	–	3,500	3,500/2"	No
	2	Cooper W	Truck	1	–	3,500/2"	No
	4	Cooper W	Truck	1	–	3,500/2"	No
	5	Cooper W	Truck	1	–	3,500/2"	No
	6	Cooper W	Truck	1	–	3,500/2"	No
	8	Cooper W	Truck	1	–	3,500/2"	No
	11	Cooper W	Truck	1	–	3,500/2"	No
	13	Cooper W	Truck	–	3,500	3,500/2"	Yes
GRANT							
C L Hinds Drlg Contr	1	P-10	Truck	–	12,000	–	–
HOISINGTON							
Shirer Well Serv Co	1	Crdwll H	Truck	1	–	5,000	No
	2	Frnks	Truck	1	–	5,000	No
	3	Crdwll H	Truck	2	5,000	5,000	No

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Pulling	Can Unit Also Drill?
HOLYROOD							
Ed Rodgers Oil Well Serv	1	Crdwll HS	Truck	–	6,000	5,000/2"	No
	2	Cooper E-563	Truck	1	6,000	5,000/2"	No
LARNED							
Post & Brown Well Serv	7	Frnks	Truck	1	6,000	5,000/2½"	No
	15	Frnks	Truck	1	7,000	6,000/2½"	No
LIBERAL							
Pool Well Serv Co	20	Wlsn Sp.	Truck	2	10,000	8,000/2½"	No
MADISON							
Barnard Well Serv	6	Cooper W	Truck	–	–	3,000	No
	7	Cooper W	Truck	–	–	3,000	No
	9	Cooper W	Truck	–	–	3,000	No
	12	Cooper W	Truck	–	3,000	3,000	Yes
	13	Cooper W	Truck	–	–	3,000	No
	15	Cooper E-42	Truck	–	–	6,000	No
	16	Cooper M-42	Truck	–	5,000	4,000	No
McPHERSON							
Anderson Oilwell Serv	1	Crdwll HS-814	Truck	–	–	4,000/2"	No
	2	Crdwll HS-846	Truck	–	–	4,000/2"	No
MEDICINE LODGE							
Clarke & Dennis Well Serv Inc	14	Crdwll AH	Truck	2	6,000	5,500	No
	15	Frnks	Truck	1	8,000	7,000	No
	16	Frnks	Truck	2	8,000	7,000	Yes
PEABODY							
Kent Well Serv Co	14	Cooper W	Truck	1	–	3,500/2"	No
PLAINVILLE							
Chase Well Serv Inc	3	Frnks TM-65	Truck	1	–	8,000/2" 7,000/2½" 6,000/3"	–
	4	Frnks TM-44	Truck	1	–	6,000/2" 5,500/2½" 4,500/3"	–
R O W S Co Inc	1	Crdwll H	Truck	–	5,000	5,000/2"	No
PRATT							
Chase Well Serv Inc	6	Frnks DTM	Truck	2	6,500	6,000/2" 5,500/2½" 4,500/3"	No
RUSSELL							
Copeland Well Serv	1	Frnks 5000	Truck	–	–	4,000	No
Ivan Holt Well Serv	1	Crdwll KS	Truck	–	–	6,000	No
	2	Crdwll HS	Truck	–	–	5,000	No
	3	Crdwll KS	Truck	–	–	6,000	No
R O W S Co Inc	3	Crdwll H	Truck	–	5,000	5,000/2"	No
	4	Crdwll H	Truck	–	5,000	5,000/2"	No
Chas A Sipes Well Serv	1	Crdwll HS	Truck	–	–	4,500/2"	No
STAFFORD							
Post & Brown Well Serv	6	Crdwll	Truck	1	6,000	5,000/2½"	No
	10	Crdwll	Truck	1	6,000	5,000/2½"	No
	17	Frnks	Truck	1	6,000	5,000/2½"	No
	19	Frnks	Truck	1	6,000	5,000/2½"	No
KENTUCKY							
HENDERSON							
Browning Well Serv Inc	231	Crdwll Q	Truck	1	–	3,500/2"	No
	235	Crdwll Q	Truck	1	–	3,500/2"	No
	239	Wichtex	Truck	1	–	3,500/2"	No
	241	Crdwll Q	Truck	1	–	3,500/2"	No
	245	Crdwll Q	Truck	1	–	3,500/2"	No
LOUISIANA							
EMPIRE							
Bayou Well Works Inc	Bge 1	Wlsn	Barge	1	12,500	–	–
GALLIANO							
Lafourche Workover H Drlg Co Inc	2	Wlsn Mogul	Trailer	–	11,000	11,000/2"	Yes
GROSSE TETE							
Booksh Well Serv	1	Cooper SkyTop	Truck	–	13,500	15,000	Yes
	2	Cooper SkyTop	Truck	–	13,500	15,000	Yes
	3	Cooper	Truck	–	13,500	–	No
LA FAYETTE							
Black Gold Well Serv	1	Crdwll H	Skid Mt'd	1	Concentric Tubing		No
	2	Wlsn	Trailer	1	Concentric Tubing		No
	3	Cooper	Skid Mt'd	1	Concentric Tubing		No
J & M Oil Well Serv Inc	1	Wlsn Gnt	Skid Mt'd	–	14,000	14,000	Yes
	2	Wlsn Gnt	Skid Mt'd	–	14,000	14,000	Yes
Richey Drlg & Well Serv	1	Emsco GB-160T	Trailer	–	–	–	Yes
	2	Beth S45-E	Trailer	–	–	–	Yes
	4	Emsco GB-250T	Trailer	–	–	–	Yes
	5	Beth S45-E	Trailer	–	–	–	Yes
LOCKPORT							
Rayburn Well Serv Inc	1	Frnks 65-TD	Truck	–	–	10,000	Yes
	2	Frnks 65-TD	Truck	–	–	10,000	Yes
	4	Frnks Expl	Truck	–	–	13,000	Yes
NEW IBERIA							
Bayou Well Works Inc	51	Wlsn	Truck	1	12,500	–	–
	58	Wlsn	Truck	1	12,500	–	–
	63	Wlsn	Truck	1	12,500	–	–
	70	Brwstr	Truck	1	15,000	–	–
	87	Cooper	Truck	1	12,500	–	–
OIL CITY							
B & B Oil Well Serv	1	–	Truck	2	2,500	2,750/2" 2,500/2½"	No
	2	–	Truck	1	2,500	2,000/2" 2,000/2½"	No
C & C Oil Field Serv Co	1	Wlsn Sr	Truck	–	5,000	5,000/2"	–
	2	Wlsn Sr	Truck	–	5,000	5,000/2"	–
	3	Wlsn Sr	Truck	–	–	4,500/2"	–
	4	Wlsn Sr	Truck	–	–	4,500/2"	–
	5	Wlsn Sr	Truck	–	–	5,000/2"	–
	6	Wlsn Sr	Truck	–	–	4,000/2"	–
	7	Wlsn Sr	Truck	–	–	4,000/2"	–
SHREVEPORT							
A A A Well Serv Co Inc	1	Cooper P-32	Truck	1	–	6,000/2" 4,500/2½"	No
	2	Cooper P-42	Truck	1	12,500	–	No
	3	Wlsn Sr	Truck	2	5,000	5,000/2" 3,500/2½"	Yes
	4	Wilson	Truck	2	6,500	5,000/2" 3,500/2½"	No
	15	Brwstr 70	Truck	1	11,000	–	No
SPRINGHILL							
Crusader Drlg & Serv Inc	1	Wlsn Spr	Truck	1	–	3,100/2½"	No
	2	Wlsn Spr	Truck	1	6,000	–	No
	4	Wlsn Spr	Truck	1	–	7,500/2½"	Yes
	5	Wlsn Spr	Truck	2	10,000	7,500/2½"	Yes
	7	Wlsn Spr	Truck	1	10,000	–	No
	8	Wlsn Spr	Truck	1	–	8,500/2½"	No
SULPHUR							
L & W Well Serv	2	Wlsn Spr	Truck	–	10,000	–	–
	3	Cooper L-190	Truck	–	–	10,000/2"	Yes
	4	Wlsn Spr 38	Truck	–	–	10,000/2"	No
VINTON							
Fruge Well Serv	2	Wlsn Spr	Trailer	–	12,000	–	No
	3	Wlsn Spr	Truck	1	12,000	–	No
	4	Wlsn Mogul	Skid Mt'd	–	–	12,000	No
	5	Cooper 42	Truck	1	–	12,000	No
	6	Cooper 42	Truck	–	–	12,000/2½"	No
	7	Cooper 42	Truck	–	–	12,000	No
	8	Cooper UM	Skid Mt'd	–	–	10,000	No
MICHIGAN							
REED CITY							
Mumy Well Serv	1	Frnks 4000-SD	Truck	–	6,000	6,000/2"	No
	2	Crdwll H	Truck	–	5,000	5,000/2"	No
	3	Crdwll Q	Truck	–	3,000	3,000/2"	No
	4	Cooper M	Truck	–	5,000	5,000/2"	No
MISSISSIPPI							
BOLTON							
Graham Bros Oil Well Serv	4	Crdwll K	Truck	1	–	15,000/2" 13,500/2½" 10,000/3"	No
BROOKHAVEN							
Graham Bros Oil Well Serv	1	Wlsn Spr	Truck	–	13,000	–	–
	3	Wlsn Spr	Truck	1	–	12,000/2" 10,000/2½" 8,000/3"	No
MADISON							
E B Duncan Drlg & Well Serv Co Inc	1	Frnks 5000	Truck	1	–	6,500/2½"	Yes
NATCHEZ							
Thornbrugh Well Serv Co	16	Wlsn Spr	Truck	1	–	8,500/2" 7,500/2½"	–
	18	Cooper 38	Truck	1	10,000	10,000/2" 9,000/2½"	–
	20	Wlsn Spr 38	Truck	1	–	12,000/2" 10,000/2½"	Yes
	23	Ideco	Truck	1	12,500	–	–
	24	Wlsn Spr 38	Truck	1	–	12,500/2" 11,500/2½"	Yes
MONTANA							
GLENDIVE							
Signal Oilfield Serv Inc	10	Frnks 658/65	Truck	2	12,000	–	Yes
	14	Frnks 658-65	Truck	2	10,000	–	No
ROUNDUP							
H & W Oil Well Serv	1	Fr-O-E Cooper	Truck	–	5,000	5,000/2"	No
	2	Frnks	Truck	–	6,000	6,000/2"	No
	3	Brwstr	Trailer	–	8,500	8,500/2"	No
	4	Frnks	Truck	–	3,000	3,000/2"	No
	5	Wlkr-Nr C-34	Trailer	–	8,000	8,000/2"	Yes
	6	Cooper Skytop	Self Prop	–	10,000	10,000/2"	No
NEBRASKA							
KIMBALL							
Hayden & Griffith Oil Well Serv Co Inc	204	Frnks	Truck	2	12,000	12,000/2"	Yes
R O W S Co Inc	2	Crdwll K-200	Truck	2	12,000	12,000/2"	No
	5	Crdwll K-200	Truck	2	12,000	12,000/2"	No
	6	Crdwll K-200	Truck	2	12,000	12,000/2"	No
	7	Hopper GxxA	Truck	2	15,000	15,000/2"	No
	9	Reverse Rig	Trailer	–	10,000	–	–
NEW MEXICO							
ARTESIA							
Clarke Oil Well Serv Co	2	Frnks 658	Truck	2	12,000	14,000/2" 12,000/2½" 10,000/3"	No
Neil Jackson & Sons	1	Wlsn	Truck	1	4,000	–	No
	2	Crdwll	Truck	2	3,500	3,500/2" 3,000/2½" 2,500/3"	No
	3	Wlsn Spr	Truck	2	6,000	6,000/2" 5,000/2½" 4,000/3"	No
EUNICE							
Clarke Oil Well Serv Co	5	Frnks 658	Truck	2	13,000	14,000/2" 12,000/2½" 10,000/3"	No

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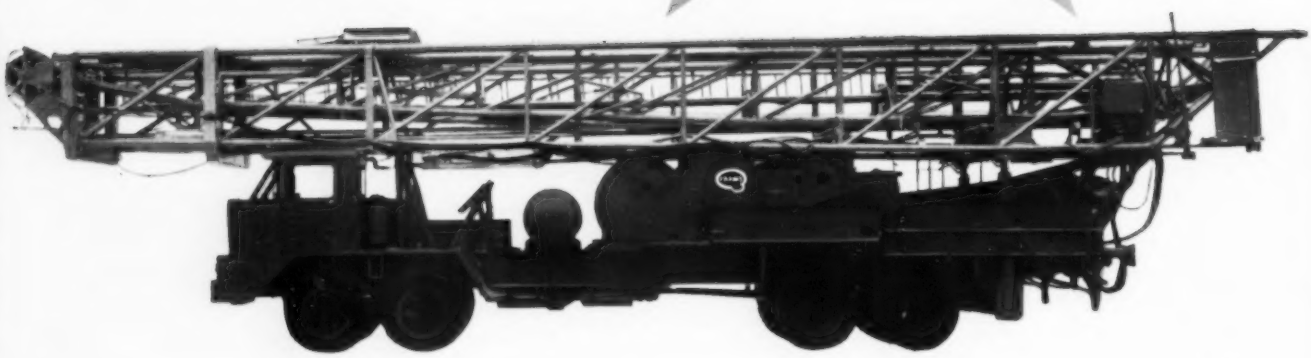

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FRANKS

DIVISION OF

CABOT SHOPS, INC.

PAMPA, TEXAS

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Pulling	Can Unit Also Drill?
Clarke Oil Well Serv Co	7	Frnks 658	Truck	2	13,000	14,000/2" 12,000/2½" 10,000/3"	No
	9	Frnks 658	Truck	2	13,000	14,000/2" 12,000/2½" 10,000/3"	No
FARMINGTON							
Bivin & Smoot Drlg Co	3	Frnks Rocket	Truck	2	10,000	10,000/2" 10,000/2½" 7,500/3"	Yes
	4	Frnks Rocket	Truck	2	10,000	10,000/2" 10,000/2½" 7,500/3"	Yes
Calif Prod Serv Inc	H-4	Hopper 1G	Truck	2	8,000	8,000	Yes
	M-1	Hopper G	Trailer	2	10,000	10,000	Yes
	M-2	Hopper G	Trailer	2	10,000	10,000	Yes
Signal Oilfield Serv Inc	6	Frnks 65/44	Truck	2	8,000	–	Yes
	15	Wlkr-Nr C-22	Truck	2	2,500	2,500	Yes
HOBBS							
Albright Well Serv Co	5	Frnks 65	Truck	1	11,000	10,000/2"	No
	12	Frnks 658	Truck	2	13,000	13,000/2" 12,000/2½"	Yes
	17	Frnks 658	Truck	2	13,000	13,000/2" 12,000/2½" 9,000/3"	Yes
	23	Frnks 658	Truck	2	13,000	13,000/2" 12,000/2½" 9,000/3"	Yes
	27	Frnks 658	Truck	2	13,000	13,000/2" 12,000/2½" 9,000/3"	Yes
	34	Frnks 658	Truck	2	13,000	13,000/2" 12,000/2½" 9,000/3"	Yes
	44	Frnks Rocket 658	Self Prop	2	13,000	15,000/2½"	Yes
Clarke Oil Well Serv Co	1	Frnks 658	Truck	2	14,000	14,000/2" 12,000/2½" 10,000/3"	No
	3	Frnks 658	Truck	2	14,000	14,000/2" 12,000/2½" 10,000/3"	No
	4	Frnks 658	Truck	2	13,000	14,000/2" 12,000/2½" 10,000/3"	No
	8	Hopper	Truck	2	14,000	14,000/2" 12,000/2½" 10,000/3"	No
	10	Frnks 658	Truck	2	13,000	14,000/2" 12,000/2½" 10,000/3"	No
J F McAdams	38	Frnks 658	Truck	–	13,000	15,000	No
	39	Frnks 658	Truck	–	13,000	15,000	No
	43	Wlsn Spr	Truck	–	8,000	8,000	No
	47	Hooper TWCB	Truck	–	13,000	15,000	No
	64	Frnks 658	Truck	–	13,000	15,000	No
	65	Frnks 658	Truck	–	13,000	15,000	No
LOVINGTON							
Southwestern Well Serv	1	Frnks 658	Truck	2	12,500	12,500	Yes
	2	Frnks 658	Truck	2	12,500	12,500	Yes
	3	Frnks 658	Truck	1	12,500	12,500	Yes
	4	Wlsn Mogul	Truck	–	15,000	15,000	Yes
	8	Frnks 658	Truck	2	12,500	12,500	Yes
	9	Crdwll KM-250	Self Prop	–	18,000	18,000	Yes
	66	Wichtex 66 Spddr	–	3	6,000	6,000	Yes
	C37	Wlkr-Nr 37	Trailer	3	8,000	8,000	–
OKLAHOMA							
CUSHING							
Glenn Gillespie & Sons	8	Cooper Skytop	Self Prop	1	–	10,000	Yes
DAVENPORT							
A - C Well Serv	1	Crdwll RL	Skid Mt'd	–	8,500	–	Yes
	2	Frnks E Tex Special	Truck	–	3,000	–	No
	3	Frnks 44	Truck	–	6,000	–	Yes
	4	Frnks Spr	Truck	–	6,000	–	No
DEWEY							
Seifried Well Serv	1	Cooper W	Truck	1	–	3,600/2"	No
	2	Cooper W	Truck	1	–	3,600/2"	No
	3	Cooper W	Truck	2	2,000	3,600/2"	No
	4	Cooper W	Truck	1	–	3,600/2"	No
LAVERNE							
Pool Well Serv Co	11	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
	12	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
	15	Wlsn Spr 38	Trailer	2	12,000	14,000/2½"	No
LINDSAY							
Chris Well Serv Co Ltd	3	Frnks 658 DTM	Truck	–	12,000	12,000	No
	4	Frnks 658 DTM	Truck	–	12,000	12,000	No
	5	Frnks 658 DTM	Truck	–	12,000	12,000	No
	7	Frnks Rocket	Truck	–	12,000	12,000	Yes
	11	Frnks 658 DTM	Truck	–	12,000	12,000	No
	14	Frnks Rocket	Truck	–	12,000	12,000	Yes
	21	Crdwll M250	Truck	2	12,000	12,000	Yes
	22	Ideco H-35	Truck	2	12,000	12,000	Yes
PAULS VALLEY							
Shebester Inc	4	Frnks	Truck	2	9,000	8,000/2"	No
	5	Frnks	Truck	2	9,000	8,000/2"	No
	10	Bath	Truck	–	13,000	–	No
	38	Frnks	Truck	2	13,000	13,000/2"	No
	45	Frnks	Truck	2	13,000	13,000/2"	No
	81	Frnks	Truck	2	13,000	13,000/2"	No
	85	Frnks	Truck	2	13,000	13,000/2"	No
	86	Frnks	Truck	2	13,000	13,000/2"	No
	108	Frnks Rocket	Truck	–	13,000	13,000/2"	No
Shebester Inc	112	Frnks Rocket	Truck	–	13,000	13,000/2"	No
	115	Frnks Rocket Tr	Truck	–	13,000	13,000/2"	No
	123	Frnks	Truck	2	15,000	15,000/2"	No
	124	Frnks	Truck	2	15,000	15,000/2"	No
	134	Frnks Clipper	Truck	–	13,000	13,000/2"	No
	139	Frnks Expl	Truck	–	13,000	15,000/2"	Yes
	150	Frnks Rocket	Truck	–	13,000	15,000/2"	No
	164	Frnks Expl	Truck	–	15,000	20,000/2"	Yes
PAWHUSKA							
Kent Oil Field Serv Inc	1	Cooper W	Truck	–	3,500	3,500/2"	No
	2	Cooper 32-26-26	Truck	–	4,000	4,000/2"	Yes
	7	Cooper W	Truck	–	3,500	3,500/2"	No
	8	Cooper W	Truck	–	3,500	3,500/2"	No
	9	Cooper M	Truck	–	4,500	4,500/2"	No
	10	Cooper W	Truck	1	–	3,500	No
	11	Cooper W	Truck	1	–	3,500/2"	No
	12	Cooper W	Truck	–	3,500	3,500	No
RIPLEY							
G H Chambers Well Serv	1	Wichtex C-65	Truck	2	7,500	7,000	No
	2	Wichtex C-65	Truck	2	7,500	7,000	No
	3	Wichtex C-65	Truck	2	7,500	7,000	No
SAPULPA							
R L Carpenter	1	Cooper W	Truck	1	3,000	3,000/2" 2,500/2½" 2,000/3"	No
SEMINOLE							
McDaniel Well Serv	1	Frnks 65-DTM	Truck	2	6,500	10,000/2" 6,500/2½"	No
	2	Frnks 65-DTM	Truck	2	6,500	10,000/2" 6,500/2½"	No
	3	Frnks 44-DTM	Truck	2	5,500	10,000/2" 6,500/2½"	No
Price-Caudle Well Serv Inc	1	Frnks 65	Truck	1	–	10,000/2" 10,000/2½" 10,000/3"	No
	2	Frnks 44	Truck	2	8,000	10,000/2" 10,000/2½" 10,000/3"	Yes
	3	Frnks 44	Truck	2	8,000	10,000/2" 10,000/2½" 10,000/3"	Yes
Young's Well Serv Inc	1	Frnks 44-DDT	Truck	–	7,000	7,000/2"	No
TEXAS							
ABILENE							
Hale-Cook Serv Co Inc	1	Wichtex	Truck	2	7,000	8,000/2½"	No
McDonald Well Serv Co	1	Frnks 44DTM	Truck	2	8,500	9,000/2" 6,000/2½"	Yes
	2	Frnks 44DTM	Truck	2	8,500	10,000/2" 7,000/2½"	Yes
	3	Wlsn Spr 38	Truck	2	8,500	10,000/2" 7,000/2½"	Yes
	4	Wichtex C-60	Truck	2	5,500	4,500/2" 3,000/3½	No
ALICE							
Mohawk Oil Well Serv	2	Wlsn Spr	Truck	2	10,000	9,000/2" 7,500/2½" 6,500/3"	Yes
	3	Wlsn Spr	Truck	2	10,000	9,000/2" 7,500/2½" 6,500/3"	Yes
	4	Wlsn Spr	Truck	2	10,000	9,000/2" 7,500/2½" 6,500/3"	Yes
	6	OCS	Truck	1	8,000	–	–
	7	Wlsn Spr	Truck	2	10,000	8,000/2"	Yes
	8	Wlsn Spr	Truck	2	10,000	8,000/2"	Yes
W M & W Well Serv Co	1	Wlsn Spr	Truck	2	7,000	7,000/2" 6,000/2½" 5,000/3"	Yes
	2	Allis Chmrs	Truck	2	8,000	10,000/2" 10,000/2½"	Yes
	3	Wlsn Spr	Truck	2	6,500	6,000/2" 5,000/2½"	Yes
	5	Wlsn Spr	Truck	2	7,500	6,500/2"	Yes
	10	Wlsn Spr	Skid Mt'd	2	8,000	–	Yes
Delbert Wallace Well Serv	3	Wlsn Spr 38	Truck	2	8,000	12,000/2"	No
	4	Wlsn Spr	Truck	2	7,500	9,500/2"	No
ALVIN							
Kay Serv Co	2	Paraffin Unit	Truck	–	12,000	–	No
	3	Paraffin Unit	Truck	–	15,000	–	No
	4	Wlsn Mogul	Truck	–	10,000	–	No
	5	Wlsn Sr	Truck	–	5,500	5,500/2"	No
Rocket Well Serv	1	Frnks 658	Truck	1	10,500	12,000/2" 10,500/2½"	Yes
	2	Wlsn 658	Truck	2	10,500	10,000/2" 9,000/2½"	Yes
Sam E Wood	1	Ideco H-20	Truck	2	–	11,000/2" 9,000/2½"	Yes
	2	Wlsn Gnt	Trailer	1	–	14,000/2" 13,000/2½"	Yes
ANDREWS							
D & G Drlg Co	5	Cooper 420-36	Truck	2	14,000	16,000	Yes
	6	Frnks 658	Truck	2	–	–	Yes
Permian Serv Co Inc	5	Cooper 119	Truck	2	13,000	13,000	Yes
	6	Frnks 658	Explr	2	15,000	15,000	Yes
	10	Wlsn Spr 38	Truck	–	12,000	12,000	No

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Pulling	Can Unit Also Drill?
Permian Well Serv Co Inc	11	Wlsn Spr 38	Truck	–	12,000	12,000	No
	12	Wlsn Spr 38	Truck	–	12,000	12,000	No
	14	Wlsn Spr 38	Truck	–	12,000	12,000	No
Williamson Well Serv Inc	14	Frnks 658	Truck	2	13,500	13,500/2½"	No
	18	Frnks 658	Truck	2	13,500	13,500/2½"	No
	20	Frnks 658	Truck	2	13,500	13,500/2½"	No
	21	Frnks 658	Truck	2	13,500	13,500/2½"	No
	22	Frnks 658	Truck	2	13,500	13,500/2½"	No
	26	Frnks 658	Truck	2	13,500	13,500/2½"	No
	33	Frnks 658	Truck	2	13,500	13,500/2½"	No
	37	Frnks 658	Truck	2	13,500	13,500/2½"	No
BAY CITY							
Ashworth Oil Well Serv Co	1	Wlsn Mogul	Trailer	–	–	10,000/2"	Yes
	2	Frnks 137	Trailer	–	–	14,000/2"	Yes
	3	Crdwll M-200	Self-Prop	–	–	16,000/2"	Yes
J P Graham	12	Wlsn Spr	Truck	1	9,000	–	No
	18	Wlsn Spr	Truck	1	9,000	–	No
	26	Wlsn Spr	Truck	1	10,000	–	No
BAYTOWN							
Beall Well Serv Co	3	Crdwll K3	Truck	–	6,500	10,000/2"	No
BIG LAKE							
Pool Well Serv Co	1	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	10	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
	14	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
	23	Wlsn Spr	Truck	1	10,000	–	No
	24	Wlsn Spr	Truck	1	10,000	–	No
	25	Wlsn Spr 38	Trailer	2	14,000	12,000/2½"	No
	31	Frnks	Truck	2	12,000	14,000/2½"	No
BIG SPRING							
Forsan Oil Well Serv	188	Frnks 658DTM	Truck	2	12,000	13,000/2½"	Yes
BOLING							
Producers Well Serv Inc	4	Cooper	Truck	2	3,500	3,500	Yes
	6	Cooper T-38	Truck	–	–	8,000	Yes
	7	Skytop	Self-Prop	–	–	12,000	Yes
CAYUGA							
Mobile Well Serv	1	Wlsn Spr	Truck	1	–	8,000/2"	No
						5,000/2½"	
	5	Wlsn Spr	Truck	1	–	8,000/2"	No
						5,000/2½"	
	8	Wlsn Spr	Truck	1	–	8,000/2"	No
						5,000/2½"	
COAHOMA							
Brewer's B & H Well Serv	3	Wlsn Sr	Truck	2	5,000	5,000/2"	No
	10	Wlsn Sr	Truck	2	5,000	5,000/2"	No
	12	Wlsn Spr	Truck	–	12,000	12,000/2"	No
	14	Wlsn Sr	Truck	2	5,000	5,000/2"	No
CONROE							
Spur Well Serv Co	2	Frnks 65-TD	Truck	1	–	8,000/2½"	Yes
CORPUS CHRISTI							
Spartan Well Serv	1	Crdwll KL	Truck	1	6,000	10,000/2"	Yes
						8,000/2½"	
						6,500/3"	
CRANE							
J R Todd Co Inc	4	Crdwll AL	Truck	2	9,000	8,000/2"	No
						6,000/2½"	
						4,500/3"	
	6	Crdwll K-200	Truck	2	13,000	13,000/2"	Yes
						12,000/2½"	
						10,000/3"	
	7	Crdwll K-200	Truck	2	13,000	13,000/2"	Yes
						12,000/2½"	
						10,000/3"	
	8	Crdwll K-200	Truck	2	13,000	13,000/2"	Yes
						12,000/2½"	
						10,000/3"	
	9	Crdwll K-200	Truck	2	13,000	13,000/2"	Yes
						12,000/2½"	
						10,000/3"	
Williamson Well Serv Inc	15	Frnks 658	Truck	2	13,500	13,500/2½"	No
	19	Frnks 658	Truck	2	13,500	13,500/2½"	No
	35	Frnks 658	Truck	2	13,500	13,500/2½"	No
DENVER CITY							
Harrison Well Serv	1	Wlsn Mogul	Truck	2	14,000	12,000/2½"	–
	2	Wlsn Mogul	Truck	2	14,000	12,000/2½"	–
EL CAMPO							
Kay Serv Co	6	B I W	Truck	–	8,000	2,000/2"	No
FORSAN							
Forsan Oil Well Serv	11	Frnks 33	Truck	1	–	3,500/2½"	Yes
	33	Crdwll 856	Truck	1	–	3,500/2½"	Yes
	44	Frnks 44TM	Truck	1	–	6,500/2½"	Yes
	658	Frnks 658	Trlr-Trk	1	–	13,000/2½"	Yes
	856	Wlsn Spr	Truck	2	11,000	10,000/2½"	Yes
FT. STOCKTON							
W L Hopper Inc	21	Cooper	Truck	–	6,500	7,000/2"	No
	22	Cooper	Truck	–	6,500	7,000/2"	No
GAINESVILLE							
B L & B Well Serv Co	1	Wichtex C-65	Truck	–	8,500	9,000/2"	No
GOLIAD							
W M & W Well Serv Co	7	Wlsn 38	Truck	2	8,500	8,800/2"	Yes
						7,500/2½"	
GOOSE CREEK							
Beall Well Serv Co	3	Crdwll K	Truck	2	6,500	10,000	Yes
GRAHAM							
Louis Pitcock Drlg Co	21	Wichtex Spdr	Trailer	3	6,000	6,000	Yes

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Pulling	Can Unit Also Drill?
GRANDFALLS							
Nichols & Freeman Well Serv	4	Wlsn Sr	Truck	2	4,500	5,000/2"	No
						4,000/2½"	
						2,500/3"	
	6	Wlsn Sr	Truck	2	4,500	4,000/2"	No
						3,500/2½"	
						2,500/3"	
	14	Wlsn Sr	Truck	2	5,000	5,000/2"	No
						4,000/2½"	
						3,300/3"	
	15	Wlsn Spr	Truck	1	–	8,000/2"	No
						5,000/2½"	
						4,000/3"	
	22	Wlsn Spr 38	Truck	2	11,000	10,000/2"	No
						10,000/2½"	
						7,000/3"	
HARDIN							
Beall Well Serv Co	2	Natl T-8	Truck	1	–	10,000	No
	4	Natl T-8-S	Truck	1	–	10,000	No
HIGH ISLAND							
Kay Serv Co	1	Wlsn Mogul	Truck	1	10,000	–	No
HOUSTON							
Blue Ridge Well Serv	1	Wlsn Spr 38	Truck	–	–	11,000/2"	Yes
	2	Crdwll K	Truck	–	–	8,000/2"	Yes
	3	M-CSCO U-24	Truck	–	–	8,000/2"	No
French Drlg & Well Serv	1	Wlsn Spr 38	Truck	1	–	10,000/2"	No
						9,000/2½"	
						6,500/3"	
	1	Skytop TC	Self-Prop	2	–	15,000/2"	No
						12,500/2½"	
						9,000/3"	
Moose Well Serv Co	1	Frnks 65-TD	Truck	1	–	8,000/2½"	Yes
Spur Well Serv Co	1	Frnks 65-TD	Truck	1	–	8,000/2½"	Yes
Stewart's Casing Crew	1	Cooper E	Truck	1	–	8,000/2"	Yes
						6,500/2½"	
	3	Cooper 420	Truck	1	–	11,000/2"	Yes
						9,000/2½"	
	5	Cooper 420	Truck	1	–	11,000/2"	Yes
						9,000/2½"	
	6	Cooper 420	Truck	1	–	11,000/2"	Yes
						9,000/2½"	
	7	Cooper TR-42	Truck	1	–	10,000/2"	No
						8,000/2½"	
	8	Cooper AP-138	Truck	1	–	10,000/2"	No
						8,000/2½"	
	9	Frnks	Skid Mt'd	1	–	10,000/2"	Yes
						8,000/2½"	
IRA							
Brewer's B & H Well Serv	16	Wlkr-Nr C-32	Truck	3	4,500	5,500/2"	Yes
	17	Wichtex 60	Truck	2	5,000	5,000/2"	No
	18	Wlsn Sr	Truck	1	–	3,500/2"	No
	19	Wichtex	Truck	1	–	3,500/2"	No
	20	Wlsn Sr	Truck	1	–	3,500/2"	No
IRAAN							
Cash Const Co	1	Wlsn Sr	Truck	–	–	3,000/2"	No
	2	Cooper	Truck	2	3,000	3,000/2"	No
	3	Crdwll	Truck	2	7,000	7,000/2"	No
JACKSBORO							
Paul Curtner Drlg Co	6	Wlsn Spr	Truck	–	7,000	7,000/2"	No
	7	Wlsn Sr	Truck	–	7,000	7,000/2"	No
	8	Wlsn Spr	Truck	–	7,000	7,000/2"	No
	11	Wlkr-Nr C-25A	Truck	–	7,000	7,000/2"	No
	12	Wlkr-Nr P-25-A	Truck	–	7,000	7,000/2"	No
KAMAY							
J W (Johnny) Birdwell Well Serv	2	Wlsn Master	Truck	2	5,500	5,500/2"	No
	3	Wichtex C-65	Truck	2	6,500	6,500/2"	No
	4	Wlkr-Nr	Truck	1	4,500	4,500/2"	No
	5	Wichtex C-65	Truck	2	6,500	6,500/2"	No
W R (John) Potter Well Serv	1	Wlsn Spr	Truck	1	–	–	No
	3	Wlsn Master	Truck	2	5,800	6,600/2"	–
KENEDY							
Copeland & Fuller Well Serv	1	Wlsn Spr 38	Truck	2	8,000	8,500/2"	Yes
						7,500/2½"	
	2	Cooper A38	Truck	2	8,000	10,000/2"	Yes
						8,500/2½"	
KILGORE							
B L & H Drlg Co Inc	1	Beth Twister	Skid Mt'd	–	–	–	Yes
	2	Wlsn Mogul	Skid Mt'd	–	–	–	Yes
	3	Beth Breeze	Trailer	–	–	–	Yes
	4	Wlsn Gnt	Skid Mt'd	–	–	–	Yes
Bivin & Smoot Drlg Co	2	Wlsn Mogul	–	2	11,500	10,000/2"	Yes
						10,000/2½"	
						7,500/3"	
Hydraulic Pipe Pulling Co	3	Wlsn Spr	Skid Mt'd	–	–	10,000	Yes
	5	Wlsn Spr	Skid Mt'd	–	–	10,000	Yes
J-B Swabbing Co Inc	2	Wlsn Spr	Truck	1	9,500	8,000/2"	Yes
						7,000/2½"	
	3	Cooper E	Tractor	1	5,000	6,000/2"	Yes
						5,000/2½"	
	5	Wlsn Spr	Truck	1	9,500	8,000/2"	Yes
						7,000/2½"	
	6	Wlsn Spr	Truck	1	9,500	8,000/2"	Yes
						7,000/2½"	
	7	Wlsn Spr	Truck	1	9,500	8,000/2"	No
						7,000/2½"	
	8	Wlsn Spr	Truck	1	9,500	8,000/2"	Yes
						7,000/2½"	
	9	Wlsn Mogul	–	1	12,000	10,000/2"	Yes
						9,000/2½"	

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Pulling	Can Unit Also Drill?
J-B Swabbing Co Inc	10	Wlsn Mogul Spr	Truck	1	9,500	8,000/2" 7,000/2½"	Yes
	19	Wlsn Spr	Truck	1	9,500	8,000/2" 7,000/2½"	Yes
Potter Bros	1	Wlsn Spr	Truck	1	–	7,500/2" 6,500/2½" 5,500/3"	Yes
	2	Crdwll	Truck	1	4,000	7,500/2" 6,500/2½" 5,500/3"	Yes
	4	Wlsn Spr	Truck	1	–	5,000/2" 4,500/2½" 4,000/3"	No
LEVELLAND							
D & G Drlg Co	1	Frnks 658	Truck	2	12,000	12,000	Yes
Permian Serv Co Inc	11	Frnks 658	Truck	2	12,000	12,000	Yes
	4	Wlsn Spr 38	Truck	–	9,000	9,000	No
	15	Wlsn Spr 38	Truck	–	9,000	9,000	No
LIBERTY							
Texas Workover & Oilwell Serv Co	3	Wlsn Spr	Truck	1	–	10,000/2" 8,000/2½"	No
	4	Wlsn Spr	Truck	1	10,000	–	No
	5	Wlsn Spr	Truck	1	10,000	–	No
LOLITA							
Stone Well Serv	1	Frnks	Truck	1	6,000	4,200	Yes
	2	Frnks	Truck	1	–	4,200	Yes
	3	Frnks	Truck	1	–	4,200	Yes
	4	Cooper	Truck	1	–	4,200	Yes
	5	Crdwll	Truck	1	–	4,200	Yes
	6	Wlsn	Truck	1	10,000	–	No
MABANK							
Mobile Well Serv	6	Wlsn Spr	Truck	1	–	8,000/2" 5,000/2½"	No
MATHIS							
W M & W Well Serv Co	9	Wlsn Spr	Truck	2	8,500	8,588/2" 7,000/2½"	Yes
MENTONE							
W L Hopper Inc	11	Cooper	Truck	–	6,000	6,000/2"	No
	12	Cooper	Skid Mt'd	–	6,000	6,000/2"	No
	13	Cooper	Trailer	–	6,000	5,000/2"	No
	14	Wilson	Truck	–	4,500	4,000/2"	No
	15	Cooper	Truck	–	–	4,500/2"	No
MIDLAND							
Basin Well Serv Inc	32	Hopper DD	Truck	2	12,500	12,500	No
	37	Hopper Derrick	Trailer	2	12,500	12,500	Yes
	38	Hopper Derrick	Trailer	2	12,500	12,500	Yes
	44	Hopper DD	Truck	–	12,500	12,500	No
	46	Hopper DD	Truck	2	12,500	12,500	No
Pool Well Serv Co	17	Wlsn Mogul 42	Trailer	2	14,000	14,000/2½"	No
	18	Wlsn Mogul 42	Trailer	2	14,000	14,000/2½"	No
	19	Wlsn Spr	Truck	1	10,000	–	–
	22	Wlsn Mogul 42	Trailer	2	14,000	14,000/2½"	No
	27	Wlsn Mogul 42	Trailer	2	14,000	14,000/2½"	Yes
	30	Wlsn Spr 38	Truck	2	12,000	14,000/2½"	No
Williamson Well Serv Inc	27	Frnks 658	Truck	2	13,500	13,500/2½"	No
	28	Frnks 658	Truck	2	13,500	13,500/2½"	No
	30	Frnks 658	Truck	2	13,500	13,500/2½"	No
	31	Frnks 658	Truck	2	13,500	13,500/2½"	No
MISSION							
J & M Well Serv	10	Cooper TC-4210	Self-Prop	2	10,000	10,000/2"	Yes
	11	Wlsn Mogul "42"	Self-Prop	2	10,000	16,000/2"	Yes
NECHES							
Mobile Well Serv	11	Wlsn Spr	Truck	1	10,000	–	–
NEW LONDON							
Maxwell Well Serv Co	1	Wlsn Spr	Truck	1	–	10,000/2" 8,500/2½" 6,500/3"	No
	2	Wlsn Spr	Truck	1	–	10,000/2" 8,500/2½" 6,500/3"	Yes
	3	Wlsn Spr	Truck	1	–	10,000/2" 8,500/2½" 6,500/3"	No
	4	Wlsn Spr	Truck	1	–	10,000/2" 8,500/2½" 6,500/3"	–
	5	Wlsn Spr	Truck	1	9,500	–	–
NOCONA							
Jack Mercer Well Serv	2	Wlsn Sr	Truck	1	–	3,000/2" 2,500/2½" 2,500/3"	No
	6	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
	7	Wichtex C-65	Truck	2	7,500	7,500/2" 7,500/2½" 6,500/3"	Yes
	8	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
	15	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
	18	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
	20	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
	33	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
NOVICE							
Pool Well Serv Co	9	Wlsn Sr	Truck	2	6,500	5,000/2½"	No
ODESSA							
Chesnut Well Serv Co	1	Frnks 658	Truck	–	13,500	13,500	No
	2	Frnks 658	Truck	–	13,500	13,500	No
	3	Frnks 658	Truck	–	13,500	13,500	No
	4	Frnks 658	Truck	–	13,500	13,500	No
	5	Frnks 658	Truck	–	13,500	13,500	No
	6	Frnks 658	Truck	–	13,500	13,500	No
	7	Frnks 658	Truck	2	13,500	–	No
Devonian Well Serv	7	Frnks 658	Truck	2	14,000	15,000/2" 14,000/2½" 11,000/3"	Yes
E & O Well Serv Co Inc	1	Crdwll S	Truck	1	13,500	–	No
P L & B Well Serv Corp	4	Frnks 658 DTM	Truck	2	13,500	13,500/2"	No
	5	Frnks 658 DTM	Truck	2	13,500	13,500/2"	No
	6	Frnks 658 DTM	Truck	2	13,500	13,500/2"	No
	7	Frnks 658 DTM	Truck	2	13,500	13,500/2"	No
	8	Frnks 658 DTM	Truck	2	13,500	13,500/2"	No
	9	Frnks 658 DTM	Truck	2	13,500	13,500/2"	No
	10	Hopper	Truck	2	13,500	13,500/2"	No
J R Todd Co Inc	1	Frnks 658DTM	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	No
	2	Frnks 658 DTM	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	No
	3	Frnks 658 DTM	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	No
Williamson Well Serv Inc	3	Frnks 658	Truck	2	13,500	13,500/2½"	No
	7	Frnks 658	Truck	2	13,500	13,500/2½"	No
	9	Frnks 658	Truck	2	13,500	13,500/2½"	No
	10	Frnks 658	Truck	2	13,500	13,500/2½"	No
	11	Frnks 658	Truck	2	13,500	13,500/2½"	No
	13	Frnks 658	Truck	2	13,500	13,500/2½"	No
	17	Frnks 658	Truck	2	13,500	13,500/2½"	No
	23	Frnks 658	Truck	2	13,500	13,500/2½"	No
	24	Frnks 658	Truck	2	13,500	13,500/2½"	No
	32	Frnks 658	Truck	2	13,500	13,500/2½"	No
	34	Frnks 658	Truck	2	13,500	13,500/2½"	No
	36	Frnks 658	Truck	2	13,500	13,500/2½"	No
ARLA							
W L Hopper Inc	16	Cooper	Truck	–	–	4,000/2"	No
	17	Cooper	Truck	–	4,500	4,000/2"	No
	18	Cooper	Truck	–	6,000	6,000/2"	No
	19	Cooper	Truck	–	4,500	4,000/2"	No
	20	Cooper	Truck	–	6,000	6,000/2"	No
PALESTINE							
Mobile Well Serv	9	Wlsn Spr	Truck	1	9,000	–	No
PERRYTON							
D & L Drlg & Serv	1	Crdwll K-200	Truck	2	13,000	10,000/2½"	No
	3	Frnks 658	Truck	1	12,000	10,000/2½"	No
	4	Crdwll AH	Truck	2	11,000	10,000/2½"	No
H & W Well Serv Co Inc	1	Wlsn Spr	Truck	1	8,500	–	No
	3	Wlsn Spr 38	Truck	2	11,500	10,000/2" 10,000/2½"	Yes
	5	Wlsn Spr 38	Truck	2	11,500	10,000/2" 10,000/2½"	Yes
	7	Wlsn Spr 38	Truck	2	13,500	12,000/2" 12,000/2½"	Yes
PETTUS							
Ballard Well Serv	6	Wlsn Spr 38	Trailer	2	12,000	15,000	Yes
	7	Hopper Hoist	Truck	2	10,000	10,000	Yes
	8	Hopper Hoist	Truck	2	10,000	10,000	Yes
Carter Well Serv	1	Wlsn Spr	Truck	2	9,500	9,500/2" 8,000/2½" 6,500/3"	Yes
	2	Wlsn Spr	Truck	2	9,500	9,500/2" 8,000/2½" 6,500/3"	Yes
	3	Wlsn Spr	Truck	2	9,500	9,500/2" 8,000/2½" 6,500/3"	Yes
PLEASANTON							
Keeney Well Serv Co	1	Crdwll	Truck	2	7,500	–	Yes
	2	Wlsn Sr	Truck	2	6,000	–	Yes
	3	Wlsn Spr	Truck	1	8,000	–	Yes
RAYWOOD							
E L Cheeney Co	7	Wlsn Spr	Truck	–	9,000	–	No
	13	Wlsn Spr	Truck	–	–	10,000/2½"	–
	14	Wlsn Spr	Truck	–	–	12,000/2"	–
	15	Wlsn Spr	Truck	–	–	–	–
	16	Wlsn Spr	Truck	–	–	–	–
	17	Wlsn Spr	Truck	–	–	–	–
	18	Wlsn Spr	Truck	–	–	–	–
	19	Wlsn Spr	Truck	–	–	–	–
	20	Wlsn Spr	Truck	–	–	–	–
	21	Wlsn Spr	Truck	–	–	–	–
RIO GRANDE CITY							
J & M Well Serv	2	Cooper E-563	Truck	2	5,500	6,500/2" 5,500/2½"	Yes
	3	Cooper E-563	Truck	2	5,500	6,500/2" 5,500/2½"	Yes
	4	Wlsn Spr	Truck	2	6,000	7,500/2" 6,500/2½"	Yes
	5	Wlsn Spr	Truck	2	6,000	7,500/2" 6,500/2½"	Yes

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Pulling	Can Unit Also Drill?
J-B Swabbing Co Inc	7	Wlsn Spr	Truck	2	6,000	8,500/2" 7,500/2½"	Yes
	8	Wlsn Sr	Truck	2	5,000	4,500/2" 3,500/2½"	Yes
	9	Cooper T-36	Truck	1	10,000	–	No
ROSENBERG							
Savely Workover & Drlg Inc	4	Frnks 658	Self-Prop	1	–	13,500/2" 12,000/2½" 7,500/3"	Yes
	5	Frnks 658	Self-Prop	1	–	13,500/2" 12,000/2½" 7,500/3"	Yes
ROYALTY							
Locke Well Serv	1	Wlsn Spr	Truck	2	8,000	8,000/2" 8,000/2½" 8,000/3"	Yes
	2	Crdwll K	Truck	1	–	10,000/2" 7,000/2½" 5,000/3"	No
	3	Wlsn Spr	Truck	2	10,000	10,000/2" 7,000/2½" 5,000/3"	Yes
Varner Oil Well Serv	1	Wlkr-Nr P-25	Truck	2	6,000	6,000/2" 5,000/2½" 3,000/3"	No
	2	Wlsn	Truck	2	–	3,000/2" 2,500/2½"	No
	3	Wlsn	Truck	2	4,000	5,000/2" 4,000/2½" 3,000/3"	No
	4	Wlkr-Nr C-23	Truck	2	3,000	5,000/2" 4,000/2½" 3,000/3"	Yes
				2	3,000	5,000/2" 4,000/2½" 3,000/3"	Yes
	5	Wlkr-Nr P-24	Truck	2	6,000	6,000/2" 5,000/2½" 3,000/3"	No
RULE							
Acme Well Serv Co	1	Wichtex C-65	Truck	2	8,000	8,000/2"	Yes
	2	Wichtex C-65	Truck	2	8,000	8,000/2"	Yes
	3	Wichtex C-65	Truck	2	8,000	8,000/2"	Yes
SAN ANGELO							
Pool Well Serv Co	4	Wlsn Spr	Truck	1	10,000	–	No
	7	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	21	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	26	Wlsn Spr	Truck	2	6,500	5,000/2½"	No
SEMINOLE							
Hoffman Oil Well Serv Co	101	Frnks 658	Truck	2	13,000	13,000/2½"	No
	102	Wlsn Spr 38	Truck	2	13,000	13,000/2"	No
	103	Wlsn Mogul	Truck	2	13,000	13,000/2"	No
	104	Frnks 658	Truck	2	13,000	13,000/2½"	No
	105	Frnks 658	Truck	2	13,000	13,000/2½"	No
	106	Frnks 658	Truck	2	13,000	13,000/2½"	No
	107	Frnks 658	Truck	2	13,000	13,000/2½"	No
Young's Well Serv Inc	2	Frnks 44-DDT	Truck	–	7,000	7,000/2"	No
	3	Frnks 65-SD	Truck	–	–	10,000/2"	No
	4	Frnks 65-SD	Truck	–	–	10,000/2"	No
SNYDER							
Brewer's B & H Well Serv	1	Wlsn Spr 38	Truck	2	12,500	12,000/2"	No
	2	Wlsn Spr	Truck	2	10,000	12,000/2"	No
	4	Wlsn Spr	Truck	2	9,500	9,500/2"	No
	5	Wlsn Spr 38	Truck	2	12,500	12,000/2"	No
	6	Wlsn Spr 38	Truck	2	12,500	12,000/2"	No
	7	Wlsn Spr	Truck	2	9,500	9,500/2"	No
	9	Wlsn Spr 38	Truck	2	12,500	12,500/2"	No
	15	Wlsn Spr	Truck	2	9,500	9,500/2"	No
Universal Oilwell Serv Inc	136	Frnks 65 DTM2	Truck	2	11,000	10,000/2" 8,000/2½" 6,000/3"	Yes
	182	Frnks 658/65	Truck	2	11,000	15,000/2" 12,000/2½" 10,000/3"	Yes
	204	Frnks 658/65	Truck	2	11,000	15,000/2" 12,000/2½" 10,000/3"	Yes
	237	Frnks Expl	Self-Prop	2	12,000	12,000/2½"	Yes
	245	Frnks 658 Expl	Self-Prop	2	10,000	10,000/3"	Yes
	246	Frnks 658 Expl	Self-Prop	2	10,000	10,000/3"	Yes
STEPHENS							
Dollins Bro's Oil Well Serv Co	1	Wichtex	Truck	–	6,000	8,000	No
	2	Wlsn Master	Truck	–	10,000	10,000	Yes
	2	Wichtex	Truck	–	6,000	8,000	No
	2	Wlsn Master	Truck	–	10,000	10,000	Yes
	3	Wlsn Master	Truck	–	10,000	10,000	Yes
SULPHUR BLUFF							
Dood Emerson Well Serv & Gen Contg	1	Cooper E-60	Truck	1	5,000	10,000/2" 7,500/2½"	Yes
SULPHUR SPRINGS							
Dood Emerson Well Serv & Gen Contg	2	Wlsn Spr	Truck	1	5,000	10,000/2" 7,500/2½"	Yes
SWEETWATER							
Pool Well Serv Co	2	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	5	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	16	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
TALCO							
Bolin Well Serv	1	Wlsn Spr	Truck	1	8,000	7,000	Yes
TUCKER							
Mobile Well Serv	4	Wlsn Spr	Truck	1	–	8,000/2" 5,000/2½"	No
VICTORIA							
Schaefer Well Serv	1	Skytop	Trailer	–	8,000	9,500	Yes
	2	Skytop	Trailer	–	14,000	14,000	Yes
Spears Well Serv Inc	1	Wlsn Spr	Truck	2	8,000	8,500/2" 6,500/2½"	Yes
	2	Wlsn Spr	Truck	2	8,000	8,500/2" 6,500/2½"	Yes
	3	Wlsn Spr	Truck	2	8,000	8,500/2" 6,500/2½"	Yes
	4	Wlsn Spr	Truck	1	8,000	–	–
	5	Skytop Wltrwt	Truck	2	8,000	10,000/2" 8,000/2½"	Yes
	6	Skytop Wltrwt	Truck	2	8,000	10,000/2" 8,000/2½"	Yes
WASKOM							
James R Brown Well Serv	1	Wlsn Spr	Truck	1	10,000	–	No
	2	Wlsn Spr	Truck	1	–	12,000/2" 11,500/2½" 6,000/3"	Yes
	3	Wlsn Spr 38	Truck	1	–	13,000/2" 13,000/2½" 8,000/3"	Yes
WICHITA FALLS							
Beuford Thompson Prod Maintainers	2	Wichtex C-65	Truck	2	6,500	6,500/2"	Yes
Deep Well Serv Co	1	Wichtex C-65	Truck	2	6,200	6,500/2" 5,500/2½"	No
McAlister Well Serv	7	Wlsn Spr	Truck	2	7,500	7,500/2" 6,500/2½"	No
	10	Wlsn Spr	Truck	2	7,500	7,500/2" 6,500/2½"	No
	20	C-25	Truck	2	7,500	7,500/2" 6,500/2½"	Yes
	42	Wichtex	Truck	2	5,000	5,000/2" 3,600/2½"	No
	45	Wichtex	Truck	1	–	5,000/2" 3,600/2½"	No
Ramey Well Serv	1	Wichtex E-75	Truck	2	8,000	14,000/2" 12,000/2½" 10,000/3"	Yes
	2	Wichtex E-75	Truck	2	8,000	14,000/2" 12,000/2½" 10,000/3"	Yes
	3	Wichtex C-60	Truck	2	5,200	6,500/2"	No
WINK							
Permian Well Serv Inc	2	Wlsn Gnt	Truck	1	–	12,000/2" 10,000/2½" 8,000/3"	No
	3	Wlsn Spr	Truck	2	10,000	10,000/2" 8,500/2½" 6,500/3"	No
	6	Wlsn Spr	Truck	2	10,000	10,000/2" 8,500/2½" 6,500/3"	No
WINNSBORO							
Winnsboro Well Serv Co	F-1	Frnks Rocket	Truck	2	6,500	8,500/2" 7,200/2½"	Yes
	F-2	Frnks Rocket	Truck	2	6,500	8,500/2" 7,200/2½"	Yes
	F-5	Frnks Spr	Truck	1	–	8,500/2" 7,200/2½"	Yes
	F-6	Frnks 44	Truck	1	–	6,000/2" 5,000/2½"	Yes
	W-4	Wlsn Spr	Truck	1	8,500	–	–
WINTERS							
Pool Well Serv Co	3	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	8	Wlsn Sr	Truck	2	6,500	5,000/2½"	No
	28	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No

WYOMING

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Pulling	Can Unit Also Drill?
CASPER							
M E Billings Well Serv Inc	1	Wlsn Mogul	Truck	1	11,000	–	–
Capshaw Well Serv Co	1	Crdwll	Truck	2	10,000	10,000/2½"	No
	2	Wilson	Self-Prop	2	10,000	10,000/2½"	No
CODY							
D & S Well Serv Co	1	Wlsn Spr 38	Truck	–	12,500	12,500/2"	Yes
	2	Wlsn Spr 38	Self-Prop	–	15,000	15,000/2"	Yes
Wyoming Well Serv Inc	23	Ideco 50-60	Truck	1	8,000	7,000/2" 6,000/2½" 4,000/3"	Yes
	24	Frnks 65/44	Truck	2	10,000	10,000/2" 8,000/2½" 6,000/3"	Yes
	25	Crdwll	Truck	2	12,000	10,000/2½"	Yes
	30	Crdwll KS	Truck	1	8,000	9,000/2" 7,500/2½" 5,000/3"	Yes
GLENROCK							
Dyer Drlg Co	6	Wlsn Spr 38	Trailer	2	10,000	–	Yes
LINCH							
Wyoming Well Serv Inc	22	Crdwll KS	Truck	1	9,000	8,000/2" 7,000/2½" 6,000/3"	Yes
	29	White L W	Truck	1	10,000	–	No
RIVERTON							
Maddux Well Serv	5	Frnks Expl Rocket	Truck	–	11,500	17,280/2"	Yes
THERMOPOLIS							
Maddux Well Serv	2	Frnks Cruiser	Truck	–	10,000	10,000/2"	Yes
WORLAND							
Maddux Well Serv	3	Frnks Rocket	Truck	–	12,500	17,280	Yes
	4	Frnks Rocket	Truck	–	10,000	10,000/2"	Yes

Canadian Well Servicing Contractors

Beta Well Serv Ltd 5930 96th St Edmonton Alberta Canada
Bevans Well Serv Ltd Wainright Alberta Canada
Calgary Oil Field Serv Ltd 133 6th Ave SE Calgary Alberta Canada
Chupp Well Serv Ltd 525A Seventh Ave SW Calgary Alberta Canada
Coralta Drlg Ltd Box 4104 Edmonton Alberta Canada
Gamache Well Serv Ltd 12 - 11244 116th St Edmonton Alberta Canada
Jennings Drlg Co (Alberta) Ltd 133 Sixth Ave SE Rm 201 Calgary Alberta Canada
Kenyons Drlg & Serv Ltd 10439 82nd Ave Edmonton Alberta Canada
Light Well Serv Co Ltd 3631 16th St SE Calgary Alberta Canada
Mac Lean Well Serv Ltd Drayton Valley Alberta Canada
Raines Well Serv Ltd 11166 73rd Ave Edmonton Alberta Canada
Redwell Serv Co Ltd 6530 100th St Edmonton Alberta Canada
Widney Oil & Drlg Co Ltd 6328 104th St Edmonton Alberta Canada

Canadian Contract Well Servicing or Pulling Units

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Pulling	Can Unit Also Drill?
ALBERTA PROVINCE							
Raines Well Serv Ltd	1	B Erie	Trailer	–	6,000	6,000/2"	Yes
	2	Cooper TC	Self-Prop	–	10,000	9,000/2"	No
BLACKFALDS							
Redwell Serv Co Ltd	7	Frnks Rocket 44	Truck	2	9,000	9,500/2" 7,000/2½" 5,000/3"	Yes
	11	Frnks Rocket 44	Truck	2	9,000	9,500/2" 7,000/2½" 5,000/3"	Yes
BRETON							
Redwell Serv Co Ltd	1	Crdwll H	Truck	1	9,000	7,000/2" 5,000/2½" 3,500/3"	No
CALGARY							
Light Well Serv Co Ltd	101	Failing 2500	Trailer	–	5,000	5,000/2"	Yes
	102	Failing 1500	Trailer	–	5,000	2,000/2"	No
	115	Frnks Rocket	Trailer	–	7,500	7,500/2"	Yes
CAMROSE							
Gamache Well Serv Ltd	2	Frnks Rocket	Truck	–	5,000	4,500/2"	Yes
CONSORT							
Beta Well Serv Ltd	6	Crdwll AH	Truck	2	–	6,000/2" 5,000/2½"	Yes
CYNTHIA							
Redwell Serv Co Ltd	12	Frnks Rocket	Truck	2	7,000	9,000/2" 7,000/2½" 5,000/3"	Yes
DEVON							
Widney Oil & Drlg Co Ltd	1	Ideco H-20	Truck	2	9,000	10,500/2" 9,000/2½" 5,500/3"	Yes
	6	Wlsn Spr	Truck	2	9,000	8,000/2" 6,500/2½" 4,000/3"	Yes
	10	Frnks Rocket 44	Truck	2	9,000	8,000/2" 6,500/2½" 4,000/3"	Yes
	12	Ideco H-35	Self-Prop	2	15,000	18,000/2" 15,000/2½" 8,000/3"	Yes
DRAYTON VALLEY							
Beta Well Serv Ltd	8	Crdwll K-201	Truck	2	–	10,000/2" 8,500/2½"	Yes
	9	Cooper W-26	Truck	2	5,000	3,500/2½"	Yes
Mac Lean Well Serv Ltd	1	Crdwll AH	Truck	–	6,500	6,000/2"	Yes
	2	Crdwll AH	Truck	–	6,500	6,000/2"	Yes
	3	Cooper Skytop	Truck	–	10,000	10,000/2"	Yes
Redwell Serv Co Ltd	5	Crdwll AL	Truck	2	9,000	7,000/2" 5,000/2½" 3,500/3"	Yes
Widney Oil & Drlg Co Ltd	9	Wlsn Spr	Truck	2	9,000	8,000/2" 6,500/2½" 4,000/3"	Yes
EDMONTON							
Redwell Serv Co Ltd	6	Crdwll AH	Truck	2	9,000	7,000/2" 5,000/2½" 3,500/3"	Yes
LEDUC							
Gamache Well Serv Ltd	3	Frnks Rocket	Truck	–	6,500	8,000/2"	Yes
LODGEPOLE							
Redwell Serv Co Ltd	10	Frnks Rocket 44	Truck	2	9,000	9,500/2" 7,000/2½" 5,000/3"	Yes
RED DEER							
Chupp Well Serv Ltd	3	Wichtex C-60	Truck	1	5,000	5,000/2"	No
	4	Wichtex C-65	Truck	–	7,500	7,000/2"	No
	5	Ideco M-25D	Truck	2	10,000	10,000/2"	Yes
Redwell Serv Co Ltd	8	Frnks Clipper 65	Truck	2	9,000	13,000/2" 10,000/2½" 7,000/3"	Yes
REDWATER							
Beta Well Serv Ltd	2	Crdwll H	Truck	1	–	5,000/2" 4,000/2½"	Yes
	3	Crdwll Mobilhst	Truck	2	–	5,000/2" 4,000/2½"	Yes
STETTLER							
Redwell Serv Co Ltd	2	Crdwll H	Truck	1	9,000	7,000/2" 5,000/2½" 3,500/3"	No
SUNDRE							
Redwell Serv Co Ltd	3	Crdwll H	Truck	2	9,000	7,000/2" 5,000/2½" 3,500/3"	Yes
	9	Frnks Clipper 65	Truck	2	9,000	13,000/2" 10,000/2½" 7,000/3"	
WAINRIGHT							
Bevans Well Serv Ltd	1	B Erie 28	Trailer	–	3,000	4,000	Yes
	2	Frnks 4000	Trailer	–	4,000	4,000/2"	–
WETASKIWIN							
Calgary Oil Field Serv Ltd	1	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	Yes
	2	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	Yes
	3	Wlsn Magul 42	Truck	2	12,000	10,000/2½"	Yes
	4	Wlsn Magul 42	Truck	2	12,000	10,000/2½"	Yes
SASKATCHEWAN							
CARNDUFF							
Widney Oil & Drlg Co Ltd	8	Wlsn Spr	Truck	2	9,000	8,000/2" 6,500/2½" 4,000/3"	Yes
	11	Frnks Rocket 44	Truck	2	9,000	8,000/2" 6,500/2½" 4,000/3"	Yes
OXBOW							
Widney Oil & Drlg Co Ltd	7	Cooper W-226	Truck	2	5,000	3,000/2½"	No

Some Casing Pulling Equipment

Contractor's Name	Rig No.	Description of Casing Pulling Equipment
KANSAS		
EL DORADO Kent Well Serv Co	12	Hydraulic casing pulling rig . . . depth capacity: 5,000 ft
TEXAS		
HOUSTON Stewart's Casing Crew	1	Truck Mounted Unit, equipped with 150 ton hydraulic jack to pull casing to 8000 ft on all P & A work.
	7	Truck Mounted Unit, equipped with 150 ton hydraulic jack to pull casing to 10,000 ft on all P & A work.
KILGORE Potter Bros	1	Wlsn Spr single drum servicing unit available for casing pulling jobs
	2	Crdwll single drum servicing unit available for casing pulling jobs
SNYDER C E Knight & Co		3 truck-mounted units, range 3 pipe. Handle rods, tubing, mudding hole, spotting cement, circulating and shooting. 2 large rigs for pulling and plugging to 16,000 ft. A smaller unit for 8,000 ft jobs. Hydraulic Jacks.

OFFSHORE RIG LOCATOR

DRILLING CONTRACTORS

An-Son Offshore Drlg Co 1221 Carondelet Bldg New Orleans 12 La
Barnwell Offshore Inc 1748 Beck Bldg Shreveport La
Continental Marine Expl Co 911 M & M Bldg Houston 2 Tex
Coral Drlg Co Inc 620 Saratoga Bldg New Orleans La
Delta Marine Drlg Co 407 The Calif Co Bldg New Orleans 12 La
Dixilyn Drlg Corp Box 3427 Odessa Tex
Global Marine Expl Co 650 S Grand Ave Los Angeles 17 Calif
Kerr-McGee Oil Industries Inc Box 711 Morgan City La
Nickles Drlg Co 518 First City Natl Bk Bldg Houston 2 Tex
Ocean Drlg & Expl Co 300 Caribe Bldg New Orleans 19 La
Offshore-Submarex Inc 36 E Mason St Santa Barbara Calif
Reading & Bates Offshore Drlg Co 610 Saratoga Bldg New Orleans 12 La
Rimrock-Tidelands Inc Box 896 New Orleans La
Rowan Drlg Co Inc 600 Saratoga Bldg New Orleans 12 La
Salt Dome Prod Co 737 Tex Natl Bk Bldg Houston 2 Tex
Sun-Marine Drlg Corp (Offshore Constr Inc) Suite 623 2975 Wilshire Blvd Los Angeles 5 Calif
Tidelands Drlg Co 215 Shell Bldg New Orleans 12 La
Western Offshore Drlg & Expl Co 3500 Cherry Ave Long Beach 7 Calif

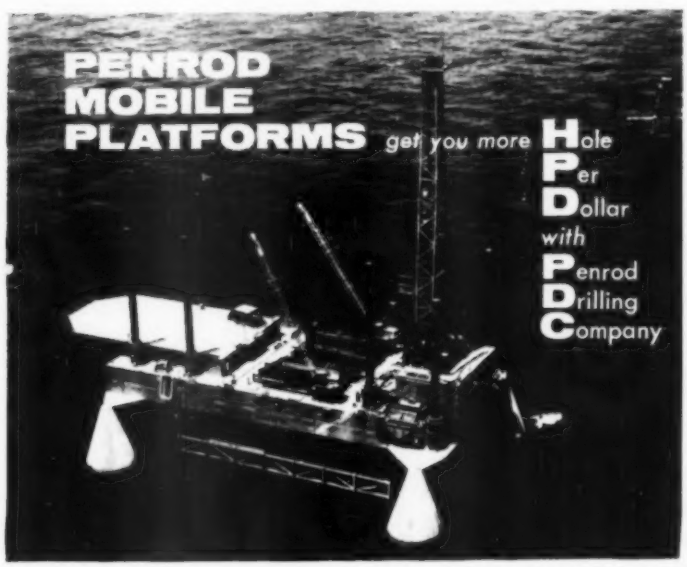
CALIFORNIA

MOBILE DRILLING BARGES

Owner's Name	Rig, Barge Name or Number	Operator Drlg for	Offshore Location—(County)	Water Depth Ft	Type Rig Power	Drwwks Make & Model	Total hp Available to Drwwks	Total hp to all Main Mud Pumps	Rated Drlg Depth with 4½" Pipe
Western Offshore Drlg & Expl Co	Rig B	Phillips	"A" Blk Elwood	168	dsl	Natl 80	1600	2100	12,000

PLATFORM-TENDER DRILLING UNITS

Western Offshore Drlg & Expl Co	Rig A	Std Cal Humble	Summerland	102	AC elec	Natl 80B	1250	1700	12,000
	Rig C	Std Cal Humble	Summerland	102	AC elec	Natl 80B	1250	1700	12,000



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TELEPHONE: UPtown 9-1521

PENROD LAND AND SEA DRILLING COMPANY

SELF-CONTAINED PLATFORMS

Owner's Name	Rig, Barge Name or Number	Operator Drlg for	Offshore Location—(County)	Water Depth Ft	Type Rig Power	Drwwks Make & Model	Total hp Available to Drwwks	Total hp to all Main Mud Pumps	Rated Drlg Depth with 4½" Pipe
Offshore-Submarex Inc	"PCS Exploit"	–	Los Angeles Harbor	–	dsl engine	Howard-Turner	175	175	3,500/3"
	"Labusca"	–	Los Angeles Harbor	–	dsl engine	Howard-Turner	165	165	2,500/3"
	"Sandab V"	–	Santa Barbara Harbor	–	dsl engine	Howard-Turner	175	175	2,500/3"
Sun-Marine Drlg Corp (Offshore Constr Inc)	"Pacific Driller 1"	Std Cal Humble	Gariota 2A	90	dsl engine	Natl 110	1500	2500	16,000

LOUISIANA

FLOATING VESSELS

Global Marine Expl Co	"CUSS-I"	Texas	Santa Barbara	20-600	dsl	Natl 80-B	1800	1400	12,000
	"Submarex"	–	Port Hueneme	20-600	dsl	Howard-Turner	–	640	3,000/2½"

MOBILE DRILLING BARGES

Barnwell Offshore Inc	"Mister Cap"	Sinclair	Eugene Is Blk 190	80	dsl-elec	Ideco E-2500	2500	2500	25,000
Coral Drlg Co	"Mr Arthur"	Self	Bay Marchand Blk 4	–	dsl-elec	Brwstr N-12-A	1250	2500	20,000
Delta Marine Drlg Co	Rig 2 "Chris Zeppa"	–	Venice	35	dsl engine	Ideco Bg Gnt	1600	1950	15,000
Dixilyn Drlg Corp	Rig 8 "Julie Ann"	Shell	Eugene Is Blk 189	70	dsl engine	Natl 1625E	2490	2490	25,000
Kerr-McGee Oil Ind Inc	Rig 47	Humble	S Timbalier Blk 35	38	dsl-elec	Emsco EDA-460	1250	1250	20,000
Nicklos Drlg Co	Rig 20	Texaco	S Marsh Is S/L 340	8	dsl engine	Natl 130	2250	2250	20,000
	Rig 21	Texaco	S Marsh Is S/L 340	8	dsl engine	Natl 130	2250	2250	20,000
Ocean Drlg & Expl Co	"Margaret"	Shell	East Bay Blk 27	–	dsl-elec	Emsco EDES	1500	1000	20,000
	"St. Louis"	Midwest	Eugene Is Blk 90	–	dsl-elec	Emsco ECB	1200	1000	15,000
	"John Hayward"	Calco	Eugene Is Blk 93	–	dsl-elec	Emsco ECA	1200	1000	15,000
	"Mr. Charlie"	Texaco	S Timbalier Blk 11	–	dsl-elec	Emsco EDES	1500	1000	20,000
Rimrock Tidelands Inc	"Rimtide"	Shell	E Cameron Blk 17	35	dsl engine	Emsco A-1500	1500	2000	20,000
	"Union Drill" Bge A	Union	Eugene Is Blk 128	70	dsl-elec	Ideco 2500	2000	2000	25,000
Rowan Drlg Co Inc	Bge 19	Calco	Main Pass Blk 69	20	dsl-elec	M-CSCO U-1220E	2250	2100	20,000
Tidelands Drlg Co	Rig 12 "Mr Gus II"	CATC	Grand Isle Blk 48	96	dsl-elec	Natl 160-E	1950	3900	25,000

PLATFORM-TENDER DRILLING UNITS

An-Son Offshore Drlg Co	"Carl B. Anderson"	CATC	West Delta Blk 45	40	dsl-elec	Emsco EDE	2550	2000	23,000
Delta Marine Drlg Co	Rig 1 "Joseph Zeppa"	–	Slidell	–	dsl-elec	Emsco JB-1250	1600	1600	15,000
Nicklos Drlg Co	Rig 22 "Ernie Miller"	Conoco	West Delta Blk 45	50	dsl engine	Natl 125	1400	–	17,000
Reading & Bates Offshore Drlg Co	"Geo M Reading"	CATC	Vermilion Blk 124	80	dsl engine	Natl 130	2000	3000	20,000
	"J C Craig"	CATC	Eugene Is Blk 208	80	dsl engine	Natl 130	2000	3000	20,000
	"Clayton G Dorn"	CATC	Eugene Is Blk 208	80	dsl engine	"Oilwell" 96	1800	2000	18,000

PLATFORM-TENDER DRILLING UNITS

Owner's Name	Rig, Barge Name or Number	Operator Drlg for	Offshore Location—(County)	Water Depth Ft	Type Rig Power	Drwwks Make & Model	Total hp Available to Drwwks	Total hp to all Main Mud Pumps	Rated Drlg Depth with 4½" Pipe
Rowan Drlg Co Inc	Rig 11 "Jack Cleverly"	CATC	Ship Shoal Blk 198	90	dsl engine	M-CSCO U-1220	2400	2250	20,000
	Rig 17 "Carle Sharpe"	CATC	Ship Shoal Blk 198	90	dsl engine	Natl 125	1305	2100	15,000
Salt Dome Prod Co	Rig 10 "Pelican"	Gulf	S Timbalier Blk 131	136	dsl engine	Beth 1013	1500	1500	28,000+
	Rig 14	Gulf	S Timbalier Blk 132	205	dsl engine	Natl 55	840	–	10,000

SELF-CONTAINED PLATFORMS

Dixilyn Drlg Corp	Rig 7	–	–	–	dsl engine	Natl 110	2475	2475	15,000
Rimrock Tidelands Inc	Rig 15	–	Morgan City	–	dsl engine	Brwstr N-12-A	2000	2000	18,000

TEXAS

MOBILE DRILLING BARGES

Continental Marine Expl Co	"M & H" No. 12	Texaco	Galveston Ft Pt 2265	35	dsl engine	Wlsn Titan 66	1875	2000	22,800

FOREIGN LOCATIONS

MOBILE DRILLING BARGES

Ocean Drlg & Expl Co	"El Dorado"	CIMA	Gulf of Campeche Mexico	–	dsl-elec	Emsco EDES	1500	1000	20,000

PLATFORM-TENDER DRILLING UNITS

Reading & Bates Offshore Drlg Co	"J W Bates"	Japanese Arabian	Persian Gulf	110	dsl engine	Natl 130	2000	3000	20,000

SELF-CONTAINED PLATFORMS

Reading & Bates Offshore Drlg Co	"C E Thornton"	Japanese Arabian	Persian Gulf	110	dsl engine	Natl 110	1300	3000	16,000

ADDITIONAL LISTINGS

U. S. Contract Rotary Drilling Rigs

Don Clawson 405 American Bldg Ada Okla
Clegg & Hunt 715 Houston Club Bldg Houston Tex
Dixilyn Drlg Corp Box 3427 Odessa Tex
Fitzpatrick Drlg Co Inc Box 639 Casper Wyo
Garvey Drlg Co Rt 2 Great Bend Kans
The Grande Corp 1610 Life of America Bldg Dallas Tex
Lee Drlg Co 1007 Philtower Bldg Tulsa Okla
R L Manning Co 318 Continental Oil Bldg Denver Colo
Nicklos Drlg Co 518 First City Natl Bk Bldg Houston 2 Tex
Twinoak Drlg Co 210 S Morton Okmulgee Okla

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Workover Depth, Ft
COLORADO						
WASHINGTON						
Garvey Drlg Co	12	dsl	300	Wlsn Gnt	320	6,000/3½"
KANSAS						
BARBER						
Garvey Drlg Co	8	dsl	175	Wlsn Gnt	296	5,000
FINNEY						
Garvey Drlg Co	14	dsl	175	Wlsn Gnt	296	5,000
NORTON						
Garvey Drlg Co	9	dsl	175	Wlsn Gnt	296	5,000
SEDGWICH						
Garvey Drlg Co	3	dsl	175	M-CSCO U-15	296	5,000
SEWARD						
Garvey Drlg Co	22	dsl	300	Wlsn Mogul 42	450	7,000
STAFFORD						
Garvey Drlg Co	10	dsl	175	Wlsn Gnt	296	5,000
	11	dsl	175	Wlsn Gnt	296	5,000
	15	dsl	175	Wlsn Gnt	296	5,000
LOUISIANA						
ACADIA						
Clegg & Hunt	6	stm	–	Natl 9-DMB	–	14,000
	9	btne-gas	–	Natl 50-A	–	9,800
Nicklos Drlg Co	11	stm	–	Natl	–	17,000
	14	gas-btne	–	Natl 75	1000	12,000
CAMERON						
Clegg & Hunt	7	dsl	–	Natl 75	880	11,000
	8	dsl	–	–	1275	18,000
IBERIA						
Clegg & Hunt	4	stm	–	Ideco Bg Gnt	–	15,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Avail-able to Drwwks	Rated Depth with 4½" Pipe
JEFFERSON DAVIS						
Clegg & Hunt	1	stm	–	Emsco 10	–	15,000
LAFOURCHE						
The Grande Corp	7	stm	–	Emsco	600	15,500
Nicklos Drlg Co	12	stm	–	Natl	–	17,000
ST. MARTIN						
The Grande Corp	8	stm	–	Alco BIW DNT12	500	17,250
Nicklos Drlg Co	15	gas-btne	–	Natl 80	1000	13,000
ST. MARY						
Clegg & Hunt	Bge 11	dsl-elec	2600	Ideco 2500	1900	23,000
Nicklos Drlg Co	18	gas-btne	–	Natl 110	1600	17,000
VERMILION PARISH						
Nicklos Drlg Co	10	stm	–	Natl	–	17,000
MISSISSIPPI						
MARION COUNTY						
Dixilyn Drlg Corp	6	dsl	2490	Natl 130	2490	16,000
PEARL RIVER COUNTY						
Dixilyn Drlg Corp	1	gas	1400	Natl 75	1050	13,000/3½"
PIKE COUNTY						
Dixilyn Drlg Corp	5	gas	950	Natl 100	950	14,000
MONTANA						
MUSSELSHELL						
R L Manning Co	8	dsl	550	Emsco G-500	550	7,500
ROSEBUD						
Fitzpatrick Drlg Co Inc	2	dsl	500	M-CSCO U-22	500	6,500
NEBRASKA						
KIMBLE						
Garvey Drlg Co	16	dsl	300	Wlsn Rdair	450	7,000/3½"
	17	dsl	300	Wlsn Rdair	450	7,000/3½"
	19	dsl	300	Wlsn Rdair	450	7,000/3½"
NEW MEXICO						
EDDY COUNTY						
Lee Drlg Co	1	gas-gaso	700	Natl 50	–	8,000
	2	gas-gaso	700	Natl 50	–	8,000
	4	gas-gaso	700	Natl 75	–	10,000
	6	gas-gaso	1050	"Oilwell" 76	–	13,000
	7	gas-gaso	700	Natl 50	–	8,000
LEA COUNTY						
Lee Drlg Co	5	gas-gaso	1050	Natl 100	–	13,000
OKLAHOMA						
CADDO						
The Grande Corp	9	gas	1600	Emsco A-1500	2500	25,000
CIMMARON						
Garvey Drlg Co	18	dsl	300	Wlsn Rdair	450	6,000
COAL						
Garvey Drlg Co	21	dsl	500	M-CSCO U-15	640	8,500
GARVIN						
Garvey Drlg Co	6	dsl	275	M-CSCO U-15	640	8,500
	20	dsl	300	Wlsn Mogul 42	450	7,000/3½"
OKMULGEE						
Twinoak Drlg Co	1	dsl	190	Frnks	190	3,000
	1	btne	335	M-CSCO U-34	350	5,000
PONTOTOC						
Don Clawson	1	gas-btne	370	Brwstr N-4	185	4,500
TEXAS						
CRANE COUNTY						
Lee Drlg Co	7	gas-gaso	440	Beth S-55	–	6,000
GRAYSON						
The Grande Corp	3	gas	–	Emsco	696	15,000
	5	gas	–	M-CSCO U-15	–	9,500
JEFFERSON						
Clegg & Hunt	2	stm	–	Emsco H-54	–	11,000
	10	btne-gas	–	Natl 50-A	–	10,000
TERRY COUNTY						
Dixilyn Drlg Corp	4	gas	950	Natl 80	950	14,000
UPTON COUNTY						
Dixilyn Drlg Corp	3	gas	950	Natl 100	950	14,000
WYOMING						
LINCOLN						
Fitzpatrick Drlg Co Inc	4	gas-btne	900	Wlsn Titan Rdr	900	12,500
R L Manning Co	11	gas-btne	1080	Emsco J-1000	1305	13,000
NATRONA						
R L Manning Co	7	gas-btne	750	Emsco G-500	750	8,000
	10	gas-btne	1275	Emsco J-750	1125	11,000
	17	gas-btne	765	Emsco GC-500	840	10,000
PARK CITY						
R L Manning Co	2	gas-btne	375	Emsco 300	300	5,500
	16	gas-btne	650	Natl T-32	450	6,000
SUBLETTE						
Fitzpatrick Drlg Co Inc	1	gas-btne	550	M-CSCO U-15	550	8,250/4"
R L Manning Co	5	gas-btne	750	Emsco G-500	750	8,000
SWEETWATER						
Fitzpatrick Drlg Co Inc	3	dsl-btne	300	Natl T-20	200	5,500
	5	gas-btne	600	Natl 50-A	600	8,500
	6	dsl	300	Natl T-12-S	300	4,500
R L Manning Co	6	gas-btne	900	Emsco GB-800	1125	11,000
WASHAKIE						
R L Manning Co	15	dsl	540	Emsco GB-250	340	6,000
UTAH						
SAN JUAN						
R L Manning Co	4	gas-btne	600	Emsco 450	450	7,000
	12	gas-btne	650	Emsco GA-350	450	7,000

Canadian Rotary Drilling Rigs

Petrolia Drlg Co Ltd 1410 4th St SW Calgary Alberta Canada
Souris Serv Co Ltd 940 8th Ave W Calgary Alberta Canada
Trinity Drlg Co 1205 Mercantile Securities Bldg Dallas Tex

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Avail-able to Drwwks	Rated Depth with 4½" Pipe
ALBERTA						
KEYSTONE						
Petrolia Drlg Co Ltd	7	dsl	330	Natl 50	330	7,500
PEMBINA*						
Petrolia Drlg Co Ltd	10	dsl	300	M-CSCO U-34	300	5,400
VALLEYVIEW						
Petrolia Drlg Co Ltd	11	dsl	1005	M-CSCO U-40	1005	12,000
WHITECOURT						
Trinity Canadian Drlg Co	7	dsl	875	Emsco GC-500	720	10,000
BRITISH COLUMBIA						
ALCAN HIGHWAY – MILE 248						
Trinity Canadian Drlg Co	1	dsl	995	Emsco GC-500	770	10,000
BEATTON RIVER						
Trinity Canadian Drlg Co	3	dsl	720	Emsco 350	670	7,000
	4	dsl	990	Natl 80-B	990	12,000
	5	dsl	1250	Emsco A-800	1150	15,000
SASKATCHEWAN						
ESTEVAN						
Souris Serv Co Ltd	5	–	–	Mayhew 2000	–	5,000
OXBOW						
Souris Serv Co Ltd	4	–	–	Mayhew 2000	–	5,000

U. S. Well Servicing or Pulling Units

B K Well Serv Box 365 Plainville Kans
Fish Oil Well Serv Box 809 Beeville Tex
John W Smith Well Serv Box 323 Lockport La
Dudley Elrod Taylor 118 Fifth Ave SE Cut Bank Mont
Van Norman Pipe & Supply 109 West Casper Wyo
J W Via Well Serv Box 91 Talco Tex

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Trans-ported	No. of Drums	Estimated Capacity Swab-bing	Estimated Capacity Pulling	Can Unit Also Drill?
KANSAS							
PLAINVILLE							
B K Well Serv	1	Frnks	Truck	2	7,000	7,000/2" 7,000/2-1/2" 5,000/3"	No
	1	Crdwll H	Truck	1	5,000	12,000	No
	2	Frnks TM-44	Truck	1	7,000	7,000/2" 7,000/2-1/2" 5,000/3"	
	2	Frnks 44	Truck	1	8,000	12,000	No
	3	Crdwll H	Truck	1	5,000	5,000/2" 5,000/2-1/2" 4,000/3"	No
LOUISIANA							
LOCKPORT							
John W Smith Well Serv	1	Frnks 87	Truck	–	–	12,000/2-1/2" 14,000/2"	–
MONTANA							
CUT BANK							
Dudley Elrod Taylor	3	Crdwll AH	Truck Mtd	2	7,000	5,000/2-1/2"	–
	4	Frnks 26	Truck	1	–	3,200/2-1/2"	No
TEXAS							
BEEVILLE							
Fish Oil Well Serv	1	Wlsn Spr	Truck	1	–	7,500/2" 6,000/2-1/2"	No
	2	Ideco	Truck	1	8,000	–	No
	3	Wlsn Spr 38	Truck	2	9,500	10,000/2" 10,000/2-1/2"	Yes
TALCO							
J W Via Well Serv	1	–	Truck	–	–	–	Yes
	2	–	Truck	–	–	–	Yes
WYOMING							
BIG PINEY							
Van Norman Pipe & Supply	1	Frnks	Truck	2	10,000	10,000	Yes
EDGERTON							
Van Norman Pipe & Supply	2	Crdwll	Truck	–	3,600	3,600	No

CONTINENTAL-EMSCO

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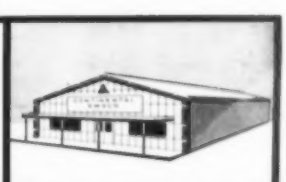

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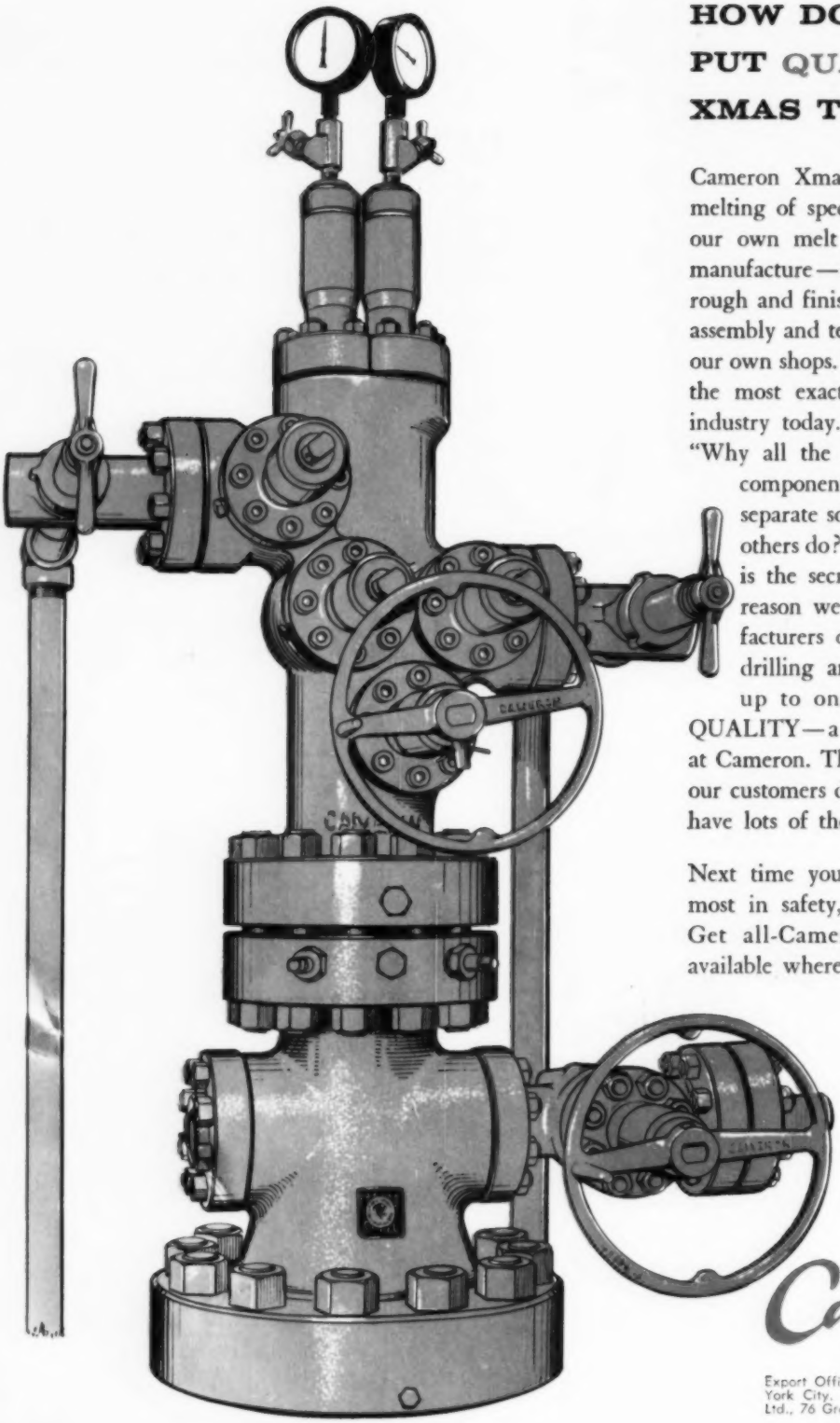

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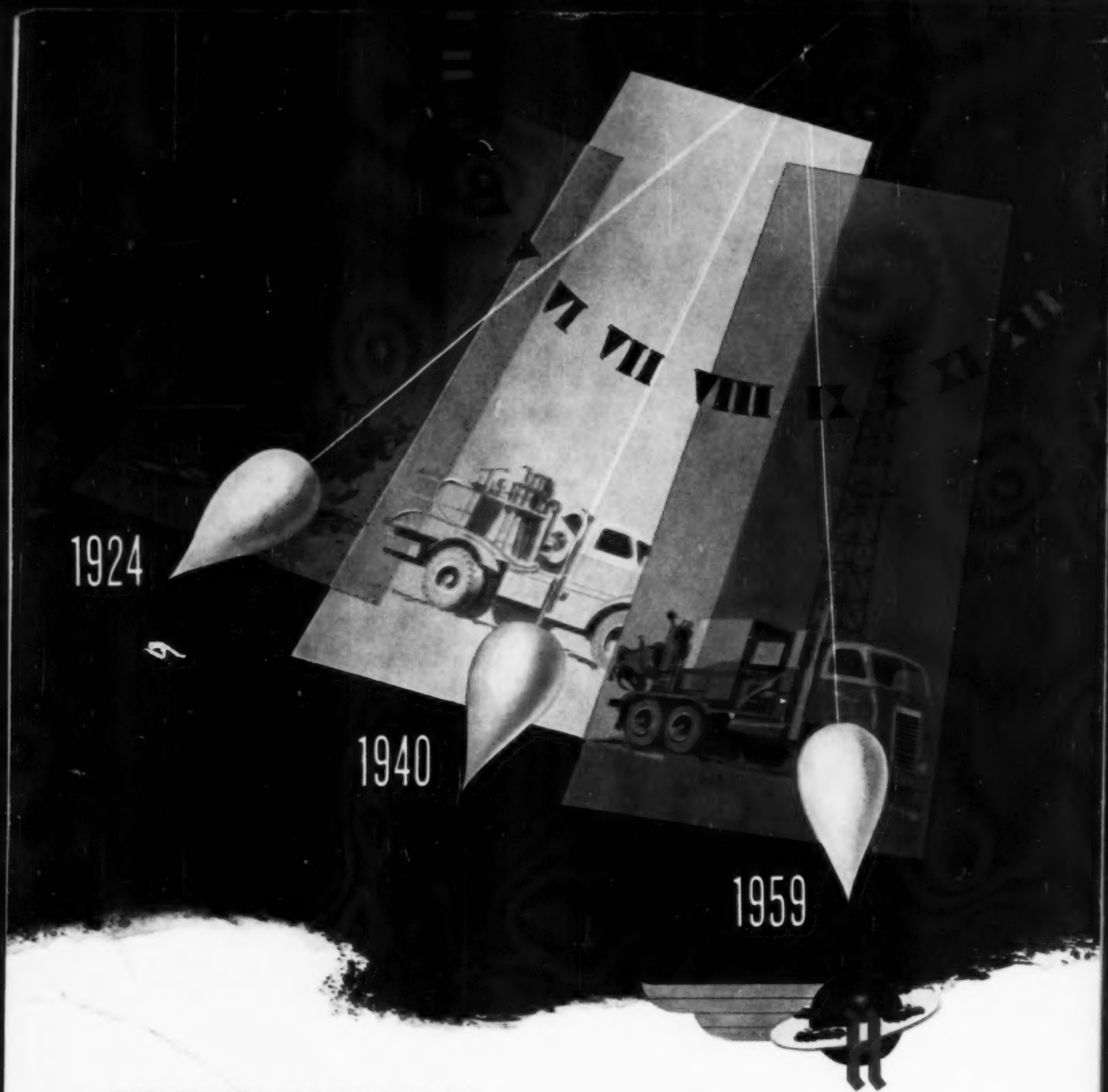

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